ASTRONOMY 2006 AUSTRALIA

A PRACTICAL GUIDE TO THE NIGHT SKY

Glenn Dawes
Peter Northfield
Ken Wallace

CALENDAR 2006

JANUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	
8	9	10	11	12	13	
15	16	17	18	19	20	21
WA 22		24	25	26	27	28
WA 29		31				

FEBRUARY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
	6	7	8	9	10	11
12		14	15	16	17	18
19	20		22	23	24	25
26	27					

MARCH

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6		8	9	10	11
12	13	14		16	17	18
19	20	21	22		24	25
26	27	28		30	31	

APRIL

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30						1
2	3	4		6	7	8
9	10	11	12	13		15
16	17	18	19	20		22
23	24	25	26	27		29

MAY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4		6
7	8	9	10	11	12	
14	15	16	17	18	19	
21	22	23	24	25	26	
28	29	30	31			

JUNE

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
	5	6	7	8	9	10
11		13	14	15	16	17
WA 18		20	21	22	23	24
25		27	28	29	30	

JULY

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	31					1
2	3		5	6	7	8
9	10		12	13	14	15
16	17		19	20	21	22
23	24		26	27	28	29

AUGUST

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1		3	4	5
6	7	8		10	11	12
13	14	15		17	18	19
20	21	22	23		25	26
27	28	29	30	31		

SEPTEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						2
3	4	5	6	7		9
10	11	12	13		15	16
17	18	19	20	21		23
24	25	26	27	28	29	

OCTOBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	
8	9	10	11	12	13	
15	16	17	18	19	20	21
	23	24	25	26	27	28
29		31				

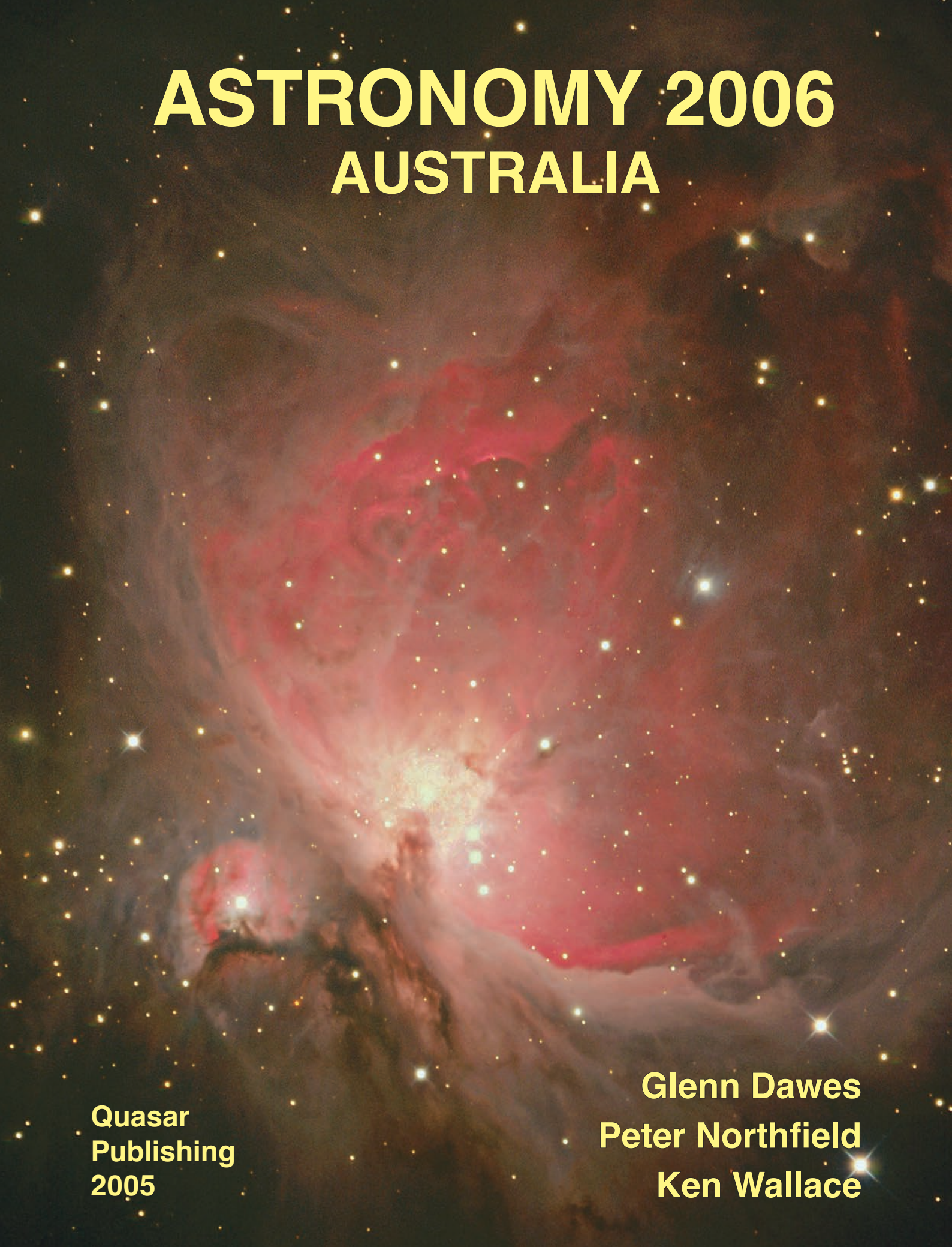
NOVEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
	6	7	8	9	10	11
12		14	15	16	17	18
19	20		22	23	24	25
26	27		29	30		

DECEMBER

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31					1	2
3	4		6	7	8	9
10	11	WA 12		14	15	16
17	18	19	WA 20		22	23
24	25	26	WA 27		29	30

ASTRONOMY 2006
AUSTRALIA



Glenn Dawes
Peter Northfield
Ken Wallace

Quasar
Publishing
2005

ACKNOWLEDGEMENTS

Some of the information for this yearbook was adapted from the following sources:

- Astronomical Almanac for the Year 2006 (US Naval and Royal Greenwich Observatories)
- Astronomical Tables of the Sun, Moon and Planets (Meeus)
- Comet orbital elements (International Astronomical Union)
- Fifty Year Canon of Lunar Eclipses 1986 – 2035 (NASA RP1216)
- Fifty Year Canon of Solar Eclipses 1986 – 2035 (NASA RP1178)
- International Astronomical Union web site
- Mathematical Astronomy Morsels (Meeus)
- More Mathematical Astronomy Morsels (Meeus)
- Mathematical Astronomy Morsels III (Meeus)
- International Meteor Organisation Calendar
- NASA/JPL website
- Burnham's Celestial Handbooks (volumes I, II, III)
- General Catalogue of Variable Stars
- Handbook of the Constellations (Vehrenberg/Blank)
- The Cambridge Guide to the Constellations (Bakich)

Data was also prepared with the assistance of the following software:

- Multiyear Interactive Computer Almanac 1800–2050 (US Naval Observatory)
- Win Occult version 3 (Herald)
- Deep Space version 5.56 (David Chandler Company)
- Voyager II, the Interactive Desktop Planetarium version 2.2 (Carina Software)
- TheSky for Mac version 5 (Software Bisque)
- Ephemeris Tool (Dings)

Thanks to David Malin, Peter Skilton and John Sarkissian for the lead articles and Greg Bryant for the comet text. As usual, we are pleased to display the astrophotographic skills of Australian amateur astronomers. In particular, we wish to thank Robert Price and Joe Cauchi for allowing us to use their images for so many years.

We would like to acknowledge the following individuals for that vital job of proofreading. These tortured souls have been with us a number of years. Our thanks go to Greg Bryant, Brenda McNamara, David Frew and Rob McIntyre.

Illustrations

- The front cover. Main picture is a stellar spire in the Eagle Nebula in Serpens, and the insert is the barred spiral galaxy, NGC 1300. Both images were taken by the ASC instrument on the Hubble Telescope. Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)
- Inside front and rear covers; Hubble Ultra Deep Field in Fornax, credit NASA, ESA, S. Beckwith (STScI) and the HUDF Team.
- Page 1, Great Nebula in Orion (M42) by Joe Cauchi (Sydney, NSW).
- 'Lunatic Ideas' images (pp. 5–7): James Webb Telescope copyright ESA, Lunar Observatory concept is an acrylic painting by Les Bossinas (ERC, Inc)/NASA and Clementine image NASA.
- Pages 8, 9. Aurora from Mt Canopus Observatory. A composite of five images taken by Shevill Mathers using a Nikon D100 camera through a Nikkor 28mm, f/2.8 lens.
- Page 15. Boy with Binoculars painting by Don Davis.
- Page 43. Light curve graph of V854 Centauri, Peter Williams (Sydney, NSW)
- Page 56. This image was taken by Joe Cauchi using a 250mm f/4 telescope. A 25 minute exposure using hypered Kodak 2415 film.
- Page 60. Mosaic of lunar images taken by Robert Price, Bethanga Victoria using an SBIG ST7 camera through a Celestron 11.
- Sources, Courses section: page 142 Wollongong Science Centre and Planetarium courtesy Glen Moore, page 143 Magellan Observatory by Zane Hammond and page 144 Great Barrier Reef Observatory by Ray Johnston.
- Rear cover, a twilight fountain of nitrogen blue and purple aurora over the southern horizon near Adelaide in 2003, by Kearn Jones using slide film.

Text, photographs and illustrations not otherwise credited are by the authors.

© Glenn Dawes, Peter Northfield and Ken Wallace 2005

This book is copyright. Apart from any fair dealings for purposes of private study, criticism or review, as permitted under the Copyright Act, no part may be reproduced by any process without written permission. Inquiries should be made to the publishers.

ISBN 0 9756070 1 4

Published in October 2005 by:

Quasar Publishing
PO Box 85, Georges Hall NSW 2198 Australia

Fax: (02) 8814 5331
Phone: (02) 8814 5332 (answering machine)
Email: info@quasarastronomy.com.au
Web: www.quasarastronomy.com.au

Additional copies of this book may be purchased directly from the publishers. Contact Quasar as above for further information.

CONTENTS

Calendar . . . . . .Inside front cover
Acknowledgements 2
Introduction 4
Lunatic Ideas 5
and the most Sublime of the Sciences
Aurora Australis – Fire in the Sky 8
45 Years of Discovery at Parkes 10

Part I – Monthly Guide

We are all Beginners 14
A word about Binoculars 15
How do I use this book to plan my observing? . . 16
Monthly section explanation 17
Movement of the Planets 19
Visibility of the Planets 20
Planet Positions 21
January 22
Probing the Planets – Update 2006
February 26
Naked Eye Challenge
March 30
Constellations in 3D
April 34
Shades of Messier
May. 38
Comet Schwassmann-Wachmann 3
June. 42
V854 Centauri — A Strange Star!
July 46
The Great Moon Hoax
August 50
A Southern Analemma
September 54
The Reflex Finder
October. 58
Asterisms
November 62
Transit Trivia
December 66
The Star Of Bethlehem
All Sky Maps. 70

Part II – The Solar System

Introduction 80
Magnitude and Size diagrams 81
Solar System Data 82
Declination and Meridian Passage diagrams . . . 84
Sun 85
Eclipses 89
Moon 90
Lunar Occultations 94
Mercury 103
Venus 107
Mars 109
Jupiter 110
Saturn 118
Uranus 122
Neptune 123
Pluto 125
Minor Planets 128
Comets 130
Meteor Showers 134

Part III – Appendices

Constellations 135
Stars – Introduction 135
Messier and other Non Stellar Objects. 136
Brightest and Nearest Stars 138
Rise and Set Time Corrections 139
Julian Date 140
Sidereal Time. 140
Photographic Exposure Guides 140
Places of Astronomical Interest 141
Courses and Sources of Information 146
Societies 149
Glossary 151
Greek Alphabet. 152
Index . . . . . .inside back cover

INTRODUCTION TO THE 2006 EDITION

Welcome to Astronomy 2006, our first full colour edition!

We are always pleased to highlight the contributions made by Australia to astronomy. This issue we focus in on the Parkes Radio Telescope, 'The Dish'. We thank John Sarkissian for giving us a riveting history of what is a remarkable facility. David Malin has always been supportive of our publications with his wonderful images. This year we see another side of David when he speculates on the advantages of an observatory on the Moon; although in recent years you would be forgiven for thinking this is in the realm of fantasy. With the renewed American interest in lunar manned exploration, who knows what is install. Our new full colour ability has allowed us to finally pay tribute to an area any of us can enjoy, providing you live far enough south – Aurorae. Peter Skilton gives us a great introduction to this unique atmospheric phenomenon.

With regard to observing in 2006, a highlight will be the transit of Mercury in November. One of the fragments of the freshly split comet Schwassmann-Wachmann 3 may present a naked eye display in May, with its companion being visible in binoculars (fingers crossed). As usual, our monthly feature articles cover quite a diverse range of interests:

- A review of the performance of the various Solar System probes and what 2006 has in store
- Observing Jupiter's satellite Callisto, with the unaided eye!
- Seeing the constellations in 3D
- We have heard of the NGC but what are the Caldwell and Bennett Catalogues?
- Observing an unusual variable star
- The Great Moon Hoax
- A Southern Hemisphere analemma
- Everyone can see asterisms
- Try a reflex finder, you'll never look back!
- How about some useless information on transits?
- What was the Star of Bethlehem?

Part I of Astronomy 2006 is intended as a general quick reference section for those wishing to see which planets are up tonight and when is the best time to observe them. This section is ideal for those just starting their exploration of the night sky. The Sky View diagrams are an easy way for you to find the brighter planets and constellations. The All Sky Maps cover the entire night sky we live under in the Southern Hemisphere. These pages compress the sky into nine, easy to use maps. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, includes sections on astronomical places of interest and the amateur societies, ideal for the beginner. We also would like to recommend to readers our website www.quasarastronomy.com.au. There are links to all of the sites listed in Part III of this book.

Astronomy, like any science, may seem to be swamped in jargon. Unfortunately, it is impossible to avoid such words. However, where necessary, astronomical terms have been explained in the text or covered in the glossary.

Lastly, we dedicate this book to you, our readers. Other people go around with their heads down concerned about the troubles of the world or preoccupied with the every day worries of life, job and family. You, like the ape-man Moon-Watcher in 2001 A Space Odyssey, have dared to raise your eyes to the heavens! We salute you.

Glenn Dawes Peter Northfield Ken Wallace

Lunatic Ideas and the most Sublime of the Sciences

by David Malin
Anglo-Australian Observatory and RMIT University

An unexpected encounter

In October 1995, I was invited to give a talk at a most unlikely venue, Sydney's exclusive Union Club, the heartland of the Establishment. Rather surprisingly (to me at any rate), the club had a substantial group of members who were interested in science and they wanted to hear something about astronomy. I gave them a well-illustrated overview of my view of what astronomers do for a living and they gave me an excellent lunch. During lunch the questions flowed. It was soon clear that the science group was very well informed about science and I found the occasion so stimulating I struggled to finish my roast beef.

Towards the end of lunch, an elderly, sharp-featured man with a piercing gaze and mischievous smile asked me where, if money were no object, I would build an observatory. Not for the first time that day I hesitated before answering, and finally blurted out that I'd put it on the far side of the Moon.

"Ah!" he cried. "Excellent!"

He fished a crumpled piece of paper from an inside pocket. It was a photocopy from *The Sydney Morning Herald* (or maybe *The Australian*) dated sometime in 1984. It was an article advocating Australia's involvement in an observatory on the Moon, written by one W. C. Wentworth. And then I recognised him. This was none other than William Charles Wentworth IV, Australia's first Aboriginal Affairs minister in the Federal Government, lateral thinker extraordinaire and great-grandson of the original W. C. Wentworth. Bill and I met several times after that, at the club and elsewhere, to chew over ideas and pleasant lunches. I was very pleased to have made his acquaintance. At this time he was in his late 70s, charming, sharp as a tack and full of ideas. His insights and opinions about the questions of the day and the state of the planet were most entertaining, but his original question and enthusiasm made me think more carefully about a lunar observatory. The more I thought about it, the more interesting it became. What a great thing to do! If money were no object, of course, and if I had Bill Wentworth as advocate. Sadly, Bill died in 2003.

High and dry and crisp

Astronomers have long appreciated the value of observing the sky from above as much of the Earth's atmosphere as possible. The search for altitude was at first a simple desire to be above the clouds but it was soon found that mountain observatories gave steadier images over wider range of wavelengths as well as clearer nights. This search also involved an eccentric scion of a famous family, Charles Piazzi Smyth. He was the son of Admiral Smyth, author of the well known *Cycle of Celestial Objects*.

In 1856, Smyth led an expedition to Tenerife "… to ascertain how much astronomical observations may be benefited, by eliminating the lower third of fourth part of the atmosphere". He enthusiastically described the quality of telescopic images seen from the Canary Islands. "We wonder how long the learned world will delay to occupy a station, that promises so well, for greatly advancing the most sublime of the sciences." (quotes from Ref. 1). It was also from there he (successfully) tried to measure the heat radiated by the Moon. His non-scientific contemporaries must have thought him quite mad. However, this was the first measurement of infrared radiation from any astronomical object other than the Sun. In 1959, a permanent solar observatory was established on Tenerife and there is now a major international astronomical observatory on an adjacent island mountain, La Palma.

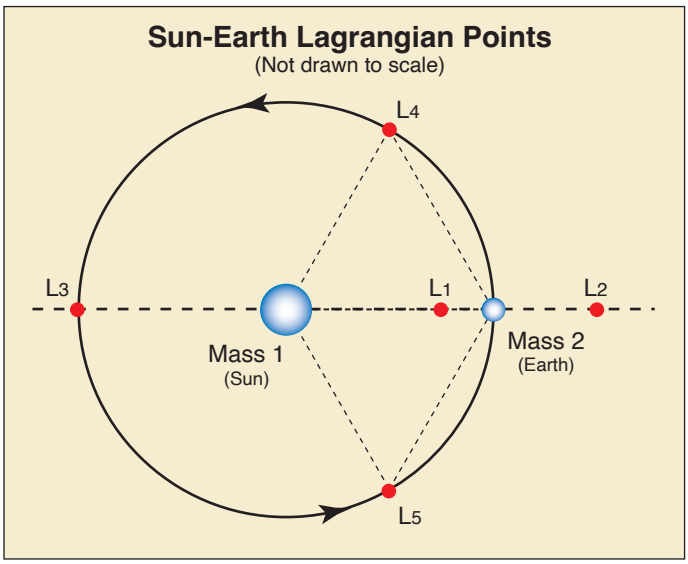
The best earth-bound telescopes are designed to focus at least 90 percent of their light from point sources into images around one tenth of an arc second across over a one degree field of view. This is very rarely achieved in practice, because the images are blurred by the turbulence of the air we look through. This ceaseless motion makes focused images dance across the detector and they are recorded as fuzzy blobs, sometimes over a second of arc in diameter. But the effect is much more than cosmetic. When the image of a point source of faint light is spread out over the CCD or photographic plate, its 'signal' is diluted and much harder to detect. At the darkest sites the atmospheric 'seeing' is a much more important limitation than light pollution. The problem is even worse with spectroscopy, where much of the light that arrives off target misses the fibre or narrow slit needed for high spectral resolution.

Though the design and location of modern telescopes has done much to minimise the effects of seeing, and adaptive optics with laser guide stars improve resolution greatly over small fields of view, there are other atmospheric problems. Water vapour absorbs increasingly strongly at infrared wavelengths beyond 1000 nm and ultraviolet light shorter than about 310 nm is completely absorbed by ozone. It is in just these regions where much fundamental astronomy remains to be done and where big scientific gains are expected.

Away from it all

The Hubble Space Telescope (HST) is a magnificent example of what can be accomplished by observing from above the Earth's atmosphere. The HST's 2.3m diameter mirror is small by current standards, but its images arrive at the detector or spectrograph unaffected by atmospheric turbulence or absorption. The stream of discoveries and spectacular images flowing from this orbiting telescope belies its modest size (two fine examples of what the Hubble Telescope has achieved can be found on the front cover of this publication – Ed). Imagine what a diffraction-limited, 10 or 15-metre instrument might do!

Of course there are plans for just such a telescope; it even has a name, the James Webb Telescope (JWT). This telescope is optimised for the infrared part of the spectrum, mainly to explore the high-redshift Universe. But it will not be in orbit around the Earth, instead it will circle the Sun at one of the several *Lagrangian Points*. These are locations in the plane of the Solar System where a small object such as a telescope appears to remain more-or-less stationary with respect to one of two much larger masses, such as the Earth and the Sun. The favoured position is L_2, which is about 1.5 million km further away from the Sun than is the Earth, and about four times the distance of the Moon. This is the location of the Wilkinson Microwave Anisotropy Probe, the highly successful WMAP satellite that was



launched in June 2001 and arrived at L_2 three months later, from where it continues to map the microwave background. This location was chosen for WMAP to minimise infrared interference from the Earth and it is for this reason that the JWT is planned to go there.

Unfortunately, at L_2 a servicing mission is currently impossible, so a telescope in orbit there cannot be repaired or upgraded in the way HST was. And as we know, HST was found to be seriously flawed when it first turned its eye to the sky in 1991, much to the chagrin of the whole astronomical community. The telescope did not fully begin its astonishingly productive career until its optics were corrected during a complex and daring Space Shuttle mission in 1993. There have been three servicing missions since, fixing troublesome solar panels, replacing astronomical instruments and the gyroscopes that are used to point the telescope. Without the service missions the telescope would not have been the success it is, and as I write this two of HST's six gyros have failed. Three are necessary for optimum observing, but two will suffice for a while. No more servicing missions are currently scheduled, so its life is now limited.

The JWT will similarly depend on gyros for pointing and tracking, though the demands placed on them will likely be less than those in the HST, and no doubt they will be better gyros. But they are still moving parts essential to the telescope's functioning. Of course, the planning documents for the telescope have all this covered and quantified, but what cannot be envisaged is the need to update the onboard instruments and detectors as new technology appears and new science demands emerge, as they inevitably will. I believe this telescope, or something bigger and better, should be on the Moon, in an appropriate crater, always sheltered from direct sunlight and earthlight, ideally on the far side. Servicing would always be difficult, risky and expensive, but it would be possible.

A multi-discipline lunar observatory

The Earth's atmosphere hardly affects radio astronomers at all, but its population does. There are powerful commercial pressures on the available radio spectrum. Though narrow 'windows' are reserved for radio observations, the signals from strong transmitters in adjacent channels spill over and swamp sensitive receivers that are tuned to respond to the feeblest cosmic whispers. The situation is made worse because some of the sources of interference are in Earth orbit, directly visible to radio antennae raised to the sky. Increasingly sophisticated signal processing and complex observing strategies are struggling to cope with the huge increase in 'noise' from un-natural satellites (including those used for astronomy), mobile phones and other sources of radio-frequency interference in the last decade. Of course, the voices of radio astronomers tend not to be heard when the other benefits of wireless communication are so evident.

Radio astronomy has revealed a universe more energetic, violent, exciting and diverse than was ever imagined and offers the most likely prospect of finding intelligent life elsewhere in the Universe. This rich seam of discovery and potential is threatened unless the radio astronomers can find some respite from the pollution that wipes out their signals. A radio HST will not do. There is nowhere in Earth orbit that is free from the man-made din. Even L_2 will be exposed to terrestrial radio noise. The solution lies elsewhere — again on the far side of the Moon, sheltered from an increasingly raucous planet.

An astronomical observatory on the Moon must embrace all wavelengths. The separation of astronomers into optical and radio camps was always an artefact of technology rather than a meaningful division, and most of the momentous discoveries of recent years have been made by astronomers working across the electromagnetic spectrum, from radio to X-ray and beyond. All of these wavelengths are accessible from the Moon, without interference or absorption. In the case of radio astronomy, very low frequencies become accessible that are difficult or impossible to detect from earth-bound telescopes. Many satellites used for astronomy have size and weight limitations imposed by the need to launch fully operational systems. On the Moon these problems disappear.

But why restrict ourselves to astronomy? Many other sciences could benefit from a lunar observatory, from studying the unique environment of the Moon itself to cosmology, planetary geology, or biology. And, like Antarctica, it could be an international venture, with no sense of ownership of the Moon, merely all countries sharing a unique resource for a scientific purpose. Like Antarctica, the Moon is believed to have water, in the form of ice in craters near the poles. If significant quantities were found it could form the basis of prolonged human habitation, as well as the source of fuel for return to Earth and explorations beyond. While I have reservations about exploiting a scarce and non-renewable resource, I feel much better about that than mining the Moon for minerals, which has also been proposed.

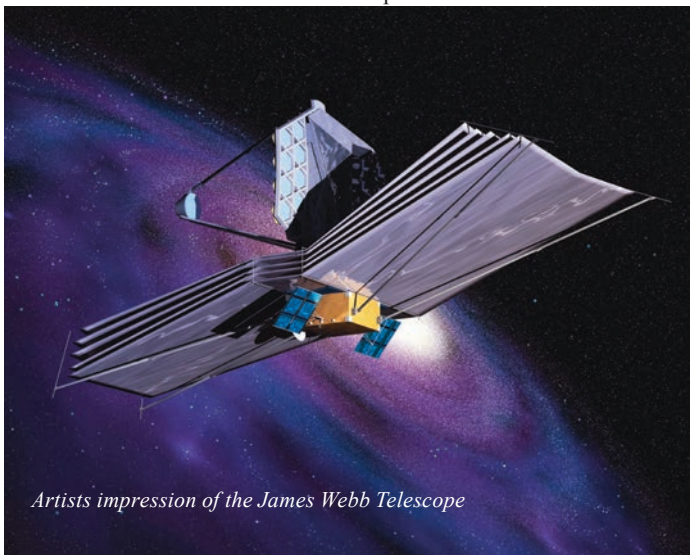
The problems are of course considerable, as is the expense, but construction of scientific facilities on the Moon will be a necessary step for its exploration and a basis for wider, manned exploration of the Solar System. The Apollo missions literally hardly scraped the surface of the science that could be done on the Moon. It seems crazy to me to commit to a Mars landing (and presumably an extensive stay) without first learning from an extended stay on the Moon. Any expertise we can gather that can help with the operation of remote, probably unmanned facilities in a harsh, inaccessible location would be invaluable.

As it happens, such expertise is being developed now, with the planning and construction of a remotely operated optical observatory on the Antarctic plateau, where the air is thin and dry and the site is harsh and isolated. Australian and other international groups have interests here, and the primary aim is to explore the infrared part of the spectrum. But only on the Moon can Mars-like isolation be replicated.

Bill Wentworth was not the first to think of this of course, indeed the idea of a lunar observatory goes back to at least to the 1950s (Ref. 2) and 1960s (Ref. 3). NASA has been funding studies on this idea, and NASA's current "Vision for Space Exploration" (Ref. 4) includes just such a facility, with robotic landers on the Moon by 2008 and a manned return by 2020. I tried to interest Bill Wentworth in the idea of an Antarctic observatory as a stepping-stone to the Moon but he said he did not have time to wait.

The President's plans

You don't have to look far on the Web to find serious commentary about proposals for a return to the Moon, followed by a lunar observatory and the prospect of using the Moon as a base for extended Solar System exploration. Some interesting websites are listed below. That idea is embedded in President George W. Bush's January 2004 establishment of a "Commission on Implementation of United States



Artists impression of the James Webb Telescope

Lunar Observatory concept; an acrylic painting by Les Bossinas

Space Exploration Policy" (Ref. 5) and endorsement of its findings (Ref. 6), and the same idea was clearly expressed in President Ronald Reagan's national space policy of January 5, 1988, which called upon NASA "to expand human presence and activity beyond Earth orbit into the Solar System".

President Bush's commission was asked to assess a civilian space program that places emphasis on the exploration of the Moon, Mars and beyond by humans and robots, and many of the arguments for and against a lunar observatory are outlined on the Space.com site (Ref. 7). Also mentioned here is Roger Angel's idea for a large, liquid-mirror telescope for surveying a limited band of sky to a great depth, rather like an ultra-deep lunar 2dF or a Sloan survey.

Not all proposals to return to the Moon are driven by science. The Artemis Project (Ref. 8) lists "Subscriptions to the Moon Miners' Manifesto and Moon Miners' Review" among the benefits of membership. The "Lunar Resources Company" (Ref. 9) is organised *… to advance and engage in space flight as a commercial enterprise, to establish and operate a permanent manned lunar base, and to transact any and all lawful business—on Earth, in outer space, and on other celestial bodies—for which corporations may be incorporated under the Texas Business Corporation Act.* One can only hope that incorporation in Texas is not a requirement for establishing a base on the Moon.

There are plans aplenty for a lunar presence but no real focus. It feels to me in some ways like the situation before the launch of the Soviet *Sputnik* satellite in 1957. This event signalled the beginning of the space race and galvanised the USA into creating NASA and ultimately to the first Moon landing, twelve years later. Now the global balance of power has changed and is changing. I was interested to read the remarks by Byron Wood, the Vice President and General Manager of Boeing Rocketdyne (Ref. 10), speaking before the US Senate Science, Technology, and Space Hearing on Space Propulsion in June 2003:

> "China plans to orbit a human, maybe this year. China has openly stated that they are aiming for the Moon, in the not too distant future. What is the future in space for the United States? Dr. Werner von Braun was fond of saying: Who will control the oceans of space? I have been somewhat disappointed in my career in that we had Americans walking on the Moon in the 1960's, but I will not live to see people return to the Moon or go beyond. Now, I believe I will see people on the Moon in my lifetime, but they will speak Chinese. Where will America be when this happens?" (Ref. 10)

America is preoccupied elsewhere, and the Chinese have not yet put a man on the Moon. I can hear Bill Wentworth now, wondering what will happen when they do, and reminding me who invented both the rocket and the Great Leap Forward.

References

1. Quoted in Anthony W. Jones, "The Canary Islands: an Astronomer's Experiment", "Sky and Telescope", Vol. 62, no. 3 (Cambridge, Mass., September 1981), pp. 199–201. and muweb.millersville.edu/~columbus/data/geo/WASHBR04.GEO
2. The Exploration of the Moon, Arthur C. Clarke, Harper & Bros., New York, 1954
3. "Radio Astronomy From The Lunar Far Side: Precursor Studies Of Radio Wave Propagation Around The Moon" Y. D. Takahashi (and extensive references therein) www.astro.gla.ac.uk/users/yuki/NVME.htm
4. www.nasa.gov/missions/solarsystem/explore_main.html (Rather thin coverage of President G. W Bush's 2004 June 16 statement)
5. www.nasa.gov/missions/solarsystem/PICT_executive_order.html
6. www.nasa.gov/missions/solarsystem/explore_main.html
7. www.space.com/businesstechnology/technology/050309_lunar_scope.html
8. www.asi.org/
9. www.tlrc.com/
10. www.spaceagepub.com/SOM/SOM_FAQ.htm

Web sites and other sources

"Astronomy from the Moon: A Second Look" by Paul D. Lowman, Jr. Mercury Magazine Vol. 29 No. 2, p31, March/April 2000 (quoted on www.spaceagepub.com/SOM/SOM_FAQ.htm)

www.jwst.nasa.gov/home/ (James Webb Telescope)

www.spaceagepub.com/SOM/SOM_FAQ.htm (Stanford Alumni Moon Project)

www.kathryncramer.com/lunar_development/2005/07/exploration_wit.html ("Exploration without science is tourism" — AAS statement)

www.spaceagepub.com/ilo/ilo.news.isr.html (International Lunar Observatory News)

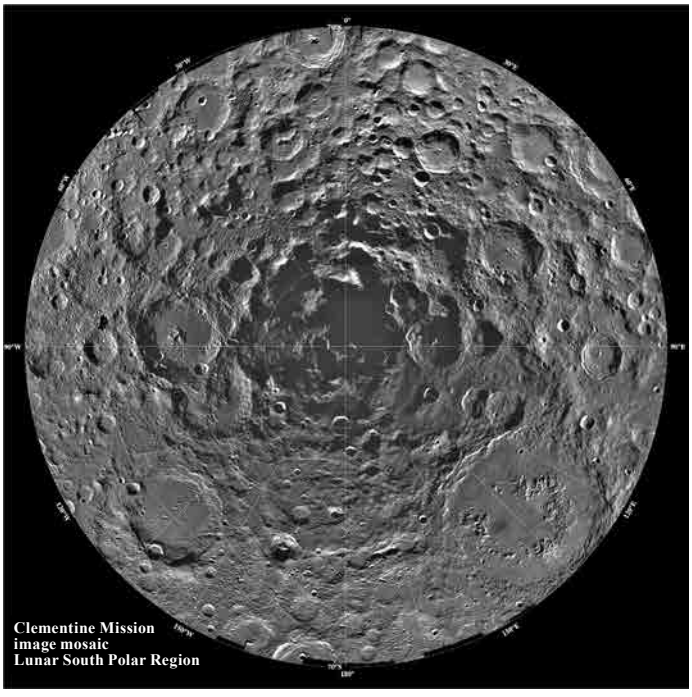
aerospacescholars.jsc.nasa.gov/HAS/cirr/em/7/5.cfm (explores the moon-to-Mars exploration options)

www.marsinstitute.info/rd/faculty/dportree/rtr/vh08-4.html (see under " Lunar Observatory case study" and " Lunar Outpost to early Mars evolution")

www.marsinstitute.info/rd/faculty/dportree/rtr/rtr-rr.html and

www.marsinstitute.info/rd/faculty/dportree/rtr/rtr-ft.html (Moon and Mars landing/colonisation bibliography and links)

aerospacescholars.jsc.nasa.gov/HAS/cirr/em/8/6.cfm (Historic Lunar Base Designs)


Clementine Mission image mosaic Lunar South Polar Region

Aurora Australis – Fire in the Sky

Peter Skilton
Director Southern Australasia Aurora Alert Network

An auroral ray, appearing like a lone searchlight next to street lights, by Paul Anderson from a suburban street in Ulverstone, Tas. in 2003.

One of the most elusive and beautiful of all natural phenomena is the aurora, produced at the boundary between Earth and space. The Northern Hemisphere experiences the *Aurora Borealis*, or *northern lights*, while we experience the *Aurora Australis*, or *southern lights*.

Many in Australia may have witnessed it, yet not realised so, and many amateur astronomers see one serendipitously while undertaking other observations. Auroras herald a time of heightened interference for sensitive satellite electronics, electrical power grid stability, and radio communications reliability. In 1989, Quebec's power grid surged and was disabled for days during unanticipated auroral storms. Thus many professional agencies take a practical the phenomenon and its causes, quite aside from those interested in discovering more of the physics and chemistry, or appreciating its awesomeness.

The story typically begins when highly energetic electrons and protons escape the Sun from powerful mass ejections near active Sunspot regions. These charged particles carry a magnetic signature of their origin, and take a few days to travel the Sun-Earth distance. Some simply miss the Earth. Others interact with our magnetosphere and, if their magnetic polarity opposes it, they will be captured and spiral toward the north and south magnetic poles, accelerating along the geomagnetic/electric field lines and entering the atmosphere giving rise to Auroras.

Depending on their energy, the particles will penetrate to 100–300 kilometres above the surface, and then collide with the rarefied atmospheric atoms and molecules present, mostly oxygen and nitrogen. Each collision may transfer some energy to the relaxed gases, boosting them to adopt one of a few possible higher energy states. Quickly the excited gases try to shed this energy and return to their original state in one or two steps by emitting visible light. This light is the aurora and the energy gap being transitioned defines its colour.

A large number of collisions may occur until the particles come to rest nearer the poles, forming the brighter region of the 'Auroral Oval', visible from space. The brightness therefore depends on how many particles are passing, how deeply they penetrate to denser regions, and on other atmospheric scattering effects and the colour sensitivity of the human eye or film.

Usually, the auroras we see are well south of us, being seen at high altitude over our horizon. In a geomagnetic storm, a high number of particles will impact the Earth, and the brightness at any point will increase until it is visible to the unaided eye. From space, the Auroral Oval appears to expand until it encompasses southern Australasia. In exceptionally rare cases, the oval continues to northern Australia and even the equator.

Green-blue auroral arcs in the south recorded by Paul Anderson in Ulverstone, Tasmania in 2004.

Reds and greens are mostly generated by oxygen atoms, while blues and purple are from nitrogen molecules exposed simultaneously to twilight or moonlight, though the different concentration and variety of atmospheric species present will give rise to their own characteristic colours, so no two auroras will be the same. Red auroras are high altitude and can be seen 1,000 km or more away. Green ones are deeper in the atmosphere and much closer to the observer and lower on the horizon.

The common Australian aurora is a red, pink, or white glow in the distance, much like a bushfire or sunset in a southeasterly to southwesterly direction, sometimes accompanied by a lower green/yellow region. This may surge up and down every few minutes, sometimes as far as the zenith depending on your latitude. In other cases, it can manifest itself as a thin fountain of light, like one or more World War II searchlights, beaming from a point over your horizon, and slowly swaying from side to side. At other times, it can be so dynamic that you have rippling sheets of colour moving around the sky.

Often the light level is weak, and the colour sensitivity of the human eye under these circumstances is relatively poor, so that the aurora is perceived and reported as whitish, though a sensitive camera will detect the true colours. Whites, pinks and yellows can also be due to mixtures of red, green and blue light much as in a television screen. The light intensity can vary with time as the atmosphere is dynamic to the particles' passage, and they may arrive in waves.

Auroras are more likely when the Sun is producing more equatorial Sunspots, normally over an 11 year cycle. However, in practice

A delicate pulsating pink and white aurora with swaying rays near Scorpius, photographed by Peter Skilton and experienced by dozens of others in 2001 at Mount Martha in Victoria.

are not so easily predictable, and sometimes (including the current cycle), a double maximum of sightings occurs. Typically in the southern states of mainland Australia, half a dozen auroras are visible per year, with double this in Tasmania, whereas only once a decade in Queensland.

A red aurora showing lower greens, recorded by Marty Rudd from his backyard in Somerville, Vic 2002. Note the ray structure on the left.

Auroras are quite unpredictable. However, if one has just occurred, and the active area on the Sun is still active when the Sun has rotated once in space, then 27 days later it may give rise to another aurora.

Auroras can occur at any time of the day or night. During daylight, they will not be observable by eye but may be detected by radio. At night-time, they are more frequent around the hour or two on either side of midnight. This is thought to be due to interactions between the trailing edge of the magnetosphere and the particles that have just missed Earth but are caught at the last moment.

A few email alert lists exist to provide space weather predictions using data from solar and geomagnetic disturbance monitoring instruments, and are good for a "heads up" notification of possible activity. The *Ionospheric Prediction Service*, a division of the Australian government, has such a geophysical alert service for Australasia, while the *Solar Terrestrial Dispatch* organisation in the USA does similarly for the Northern Hemisphere. Nevertheless, due to inherent unpredicability's, it is certainly not guaranteed as to whether any Aurora eventuates.

To help overcome this, and enable wider observations, the *Southern Australasia Aurora Alert Network* was started in 1997, and has grown by word-of-mouth to about 80 participants on its primary network across Australasia. A larger number of additional observers are on other secondary networks. Participants include scientists, amateur

A weak auroral glow as captured on standard slide film in 1984 by Bruce Tregaskis in Mount Eliza, Victoria.

astronomers, artists, photographers, weather watchers, radio hams and those in general who seek to experience an aurora.

The network consists of two components. The first is an optional real time telephone alert list (or phone tree), where participants have agreed to phone the others on the list once an aurora has actually been sighted. They can then observe or photograph it. This has worked very well over the years, enabling many auroras to be captured that would otherwise have gone unobserved.

Tom Luttrell captured by digital camera some dynamic green and yellow-rayed bands from Mount Nelson light station, Tas. in 2004.

The second component is an unlisted Yahoo group (e-southern-aurora) that acts as an email alert facility and general discussion forum focusing on the Aurora Australis. This is the only such current Aurora Australis group we know of, with others being almost universally Aurora Borealis focused. The network also has a web component with a database of hints, tips, background materials for observers and all known images back to the 1970's of the Aurora Australis, together with collated reports of sightings as they come to hand, and links to many useful websites.

All reports and photos are periodically shared for wider research purposes with the *Ionospheric Prediction Service,* the Auroral Section of the *Royal Astronomical Society of New Zealand*, and thence the *British Astronomical Association*, and the *Solar Terrestrial Dispatch* organisation.

To participate in the network, visit http://groups.yahoo.com/group/southern-aurora, or send an email to southern-aurora-subscribe@yahoogroups.com, or phone 0419 253 252. All reports and photos of auroral sightings (past or present) are eagerly sought.

Mt Canopus Observatory site, Cambridge, overlooking Hobart and the Derwent River 24/8/5 at 8pm (Shevill Mathers).

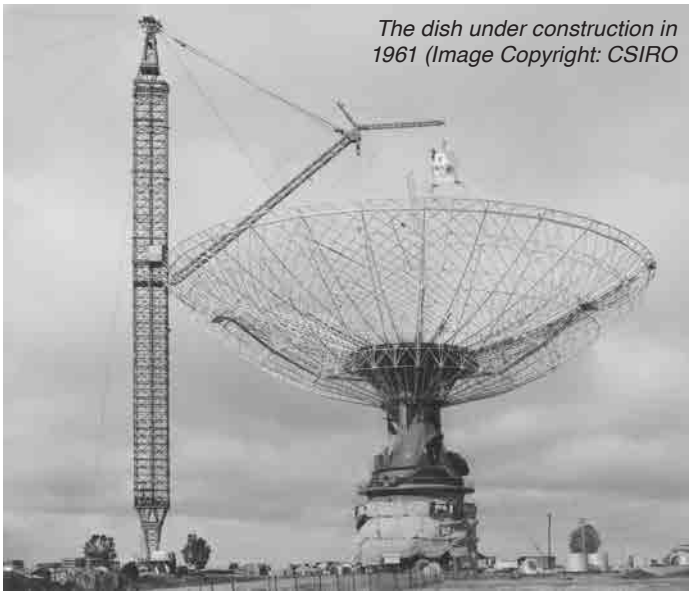
45 Years of Discovery at Parkes

John M. Sarkissian
Operations Scientist CSIRO Parkes Observatory

2006 marks the 45th anniversary of one of the world's great research instruments, the CSIRO's Parkes Observatory. We look back at the great achievements and discoveries made with this iconic instrument and recognise the contributions made to science by the many astronomers who have used it over the years.

Establishment: On 31 October 1961, after 18 months of construction, the Parkes radio telescope was commissioned and quickly became the leading instrument of its kind in the world. Dr E. G. 'Taffy' Bowen, then Chief of the CSIRO's Radiophysics Laboratory, had established that the best, all-round, instrument for continuing the laboratory's pioneering research into the field of radio astronomy would be a large, fully steerable, dish antenna. The location chosen for the antenna was the Goobang Valley in the central west of New South Wales, not far from the town of Parkes. It is a long, shallow valley known for its fertile farm fields and providing ample protection from man-made radio interference.

The 64-metre telescope was designed to CSIRO specifications by the British firm Freeman Fox (the same firm that designed and built the Sydney Harbour Bridge) and was built by the German company MAN. The noted British engineer, Barnes Wallis of "Dam Busters" fame, provided invaluable advice and ideas. For example, it was he who suggested building the telescope like an inverted umbrella, supported and pivoted from the centre. The superb structural integrity, constant upgrades to the dish surface and continued advances in electronic and computer technology have enabled the telescope to remain at the forefront of astronomy for the past 45 years. In 1988, Parkes became part of the CSIRO's Australia Telescope National Facility (ATNF).



The dish under construction in 1961 (Image Copyright: CSIRO

The Science: From the very beginning, astronomers at Parkes have made many world-class discoveries. Within months of its commissioning, the dish was involved in a major discovery that has shaped our understanding of the Universe. The quasar, 3C273, was the first ever to have its position and distance measured accurately. It was found to be the then most distant known object in the Universe and emitting enormous amounts of energy. The story of how this discovery was made is fascinating. For several years in the late 1950's and early 1960's the nature of several enigmatic, celestial radio sources was a source of fierce debate. Early in 1962, Cyril Hazard, of Sydney University, realised that one such source, 3C273, would be occulted by the Moon in early August of that year. By timing the disappearance and subsequent reappearance of the signal as it moved behind the Moon, the precise location of the source could be calculated since the position of the Moon's limb was accurately known. However, the source's position was uncertain, and the beginning of the occultation would occur either just below or just above the telescope's horizon. John Bolton, the then Director of the Parkes Observatory, didn't want to take any chances with this critical observation. He wanted to be sure that if the occultation occurred just below the telescope's horizon, he would be ready. Staff were trained and prepared to hand-crank and turn the giant gears to move the dish and track the source across the sky should there have been an unforseen power failure. Multiple chart recorders were set-up to record the observation (there were no computers in those days). John Bolton jimmied all the stops and safety cut-offs so that the dish could be driven clear to the ground. He even used his trusty hack-saw to remove several inconvenient pieces of dish structure to get it lower still. Finally, he ordered a shallow trench dug around the dish to tip it below ground level. The observations were completed on 5 August, 1962. As a precaution, two identical sets of records were taken back to Sydney by Cyril Hazard and John Bolton on different airplanes in case one crashed. The position of the source was calculated and sent to Maarten Schmidt at Mt. Palomar Observatory whereupon a spectrum was taken of the object with the giant 200 inch telescope. It was quickly realised that the object was highly red-shifted, indicating that it was extremely distant and emitting enormous amounts of energy.

A young American PhD student at Parkes, Marcus Price, made another early discovery. During the Easter of 1962, when the observatory was closed for business, he took the opportunity to make a few impromptu observations of galaxies, notably of Centaurus A. He found that these extra-galactic radio sources were highly polarised and that the direction of the polarisation varied depending on the radio frequency of the source. This change in the polarisation direction of the radio waves as a function of frequency is a sign of a magnetic field, and is referred to as Faraday rotation. This discovery lead to the realisation that our own Milky Way Galaxy possesses an immense, but weak, magnetic field. This technique has since been used by many researchers to map the magnetic fields of galaxies, most recently of the Large Magellanic Cloud by Australian astronomer Bryan Gaensler and his colleagues. Thirty years later in 1993, Marcus Price returned to Parkes as its Officer-in-Charge.

From the outset, the telescope was designed to be a survey instrument, and it has made several ground-breaking surveys, mapping our Galaxy and the Universe to unprecedented detail. Hitherto unimagined structures have been discovered, leading to a re-appraisal of our understanding of the Universe. In the mid 1970s the Magellanic Stream was discovered at Parkes by Don Mathewson and his colleagues during an HI survey of the southern skies (HI is cold hydrogen gas). This stream is a vast filament of hydrogen trailing behind the clouds and extending in a large arc across the southern sky. It now appears that the stream formed by a collision of the two Magellanic Clouds 400 million years ago, leaving a turbulent wake as they glide through a thin halo of hydrogen gas surrounding our own galaxy.

In 1997 a new instrument was commissioned that was destined to reinvigorate the telescope and propel it back to the forefront of world astronomy. This was the Parkes HI Multibeam receiver. In the past, conventional receivers (radio detectors) would sit at the focus of the telescope and view a single point in the sky. Maps were made by simply scanning the telescope back and forth in a raster scan to build up an image, much like a television picture. The multibeam receiver, on the other hand, is thirteen receivers in one. It can view thirteen adjacent points simultaneously in the sky and is comparable to a thirteen pixel camera — not much by optical standards but a great leap forward in radio. You essentially get thirteen Parkes telescopes for the price of one. With this receiver, large surveys can be performed thirteen times faster than in the past. The receiver is used to detect HI, or cold hydrogen gas, radiating at the 21cm wavelength. Several important surveys were performed which mapped the distribution of galaxies in our local universe out to 300 million light years, and which allowed astronomers to peer through the obscuring dust of the Milky Way and map the Universe lying beyond for the first time.

The study of pulsars is a major activity at Parkes. Since pulsars were first discovered at Cambridge in 1967, the Parkes radio telescope has discovered more than two thirds of the total known number. Pulsars are fantastically dense, rapidly spinning, neutron stars, which are the

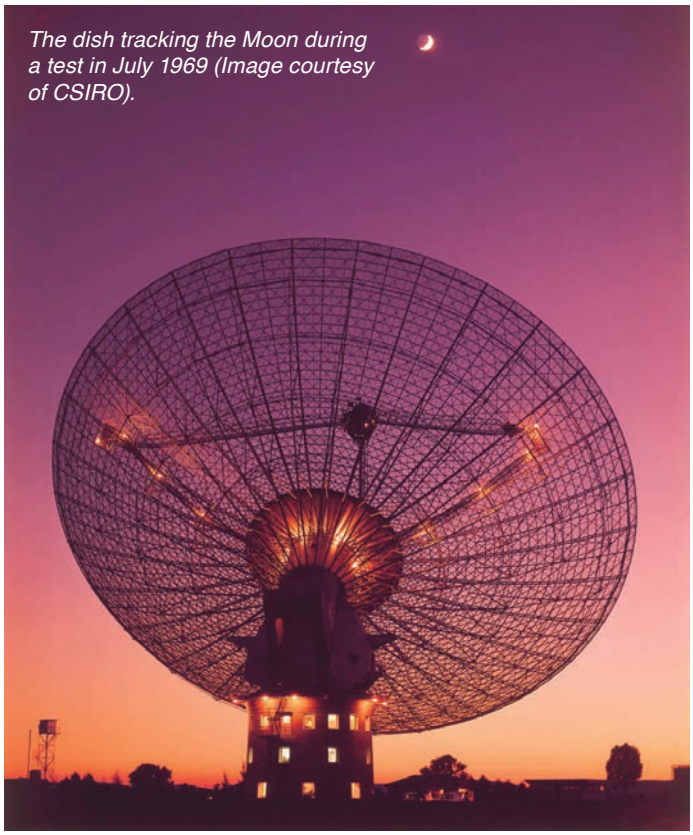
collapsed, central remnants of massive exploded stars. Observations of pulsars give information about the final stages of stellar evolution and they allow astronomers to investigate states of matter impossible to reproduce on Earth. From 1997 to the present, the multibeam receiver has been used to conduct a major survey of pulsars in the plane of the Milky Way with over 700 pulsars discovered — more than doubling the previously known number. The jewel in the crown was the discovery of the first double pulsar system in 2003. This system is the most relativistic binary system known. The two pulsars are separated by 800,000 km (about twice the Earth-Moon distance) but they take just 2.4 hours to orbit about each other. By treating the pulsars as very accurate clocks, various tests of General Relativity can be performed. In a recent 2005 discovery, it was reported that the orbits of the two pulsars are shrinking by 7mm per day as a consequence of the radiation of gravitation waves. This is in precise agreement with General Relativity.

Space Tracking: In addition to radio astronomy, the Parkes radio telescope has been involved in some of the most historic space missions to date. Despite it being only a small part of its role, it is perhaps most famous for these events. The Parkes telescope is an ideal instrument for tracking spacecraft in deep space (far from the Earth). Since it is an astronomical telescope it cannot transmit, only receive. Its large size also means that it is a very sensitive instrument. In fact, receiving spacecraft signals is no problem for Parkes since even the most feeble spacecraft transmitters at planetary distances are considered strong radio sources by astronomical standards. Whenever NASA has required a strong, reliable signal at critical moments in its various space missions it has asked Parkes to assist.

In 1962, the Parkes telescope tracked the first successful interplanetary space probe, Mariner 2, to the planet Venus. This was a test track for NASA/JPL to determine how efficiently the telescope would perform at receiving signals from planetary distances. The results were so positive that NASA modelled the large antennas of its Deep Space Network (DSN) on the Parkes telescope, which is why they were originally 64 metres in diameter. Three years later, the Mariner 4 space probe was tracked as it flew past the planet Mars. It returned the first ever close-up pictures of the surface of the red planet. The Parkes signals were combined with those received by the smaller 26 metre antennas of NASA's DSN and helped improve the initial low quality of the images. Two decades later, Parkes was involved in NASA's grand tour of the outer Solar System, this time tracking the Voyager 2 spacecraft as it flew past the giant outer planets Uranus and Neptune in 1986 and 1989 respectively. For these encounters, Parkes was linked with the giant dish at Tidbinbilla, near Canberra, to boost the signal strength and increase the bandwidth. This allowed more images to be down-linked than would have been possible with just a single antenna. Two months after the Voyager 2 Uranus encounter in 1986, the European Space Agency's (ESA) Giotto spacecraft was tracked as it passed the nucleus of Halley's Comet. The pictures received at Parkes were beamed live around the world and showed Halley's Comet to be potato-shaped and blacker than coal. More recently, the Galileo spacecraft (which orbited Jupiter) was tracked for an entire year from 1996 to 1997. By linking the Parkes radio telescope in the global tracking network, NASA was able to salvage the billion dollar mission, which was threatened following the failure of the Galileo spacecraft's main communications antenna.

From late 2003 to early 2004 there were a total of six spacecraft at Mars and many more spread out across the Solar System, all needing to be tracked. By a curious coincidence, the orbital geometry of these various spacecraft meant that during this period most of these spacecraft were clustered close to the same celestial longitude (right ascension) of Mars. In order to augment the capabilities of the DSN Canberra Station at Tidbinbilla and relieve the tracking congestion, Parkes was contracted to act as an extra receiving antenna. This freed up the DSN antennas to track the critical Mars missions requiring two way communications that included the two Mars Exploration Rovers, *Spirit* and *Opportunity*.

Apollo: Arguably, the greatest success at Parkes was its support of NASA's Apollo Moon Program. Parkes supported the manned lunar landing missions from Apollo 11 to 17. On 21 July 1969, the world watched the Apollo 11 television pictures of man's first steps on the Moon from signals received at Parkes. These signals were relayed to



The dish tracking the Moon during a test in July 1969 (Image courtesy of CSIRO).

a world-wide audience of 600 million people or one fifth of mankind at the time. The signals were received under extremely dangerous conditions. A violent squall struck the telescope just moments before the moonwalk began when the dish was at its most vulnerable, fully tipped over waiting for the Moon to rise. The track continued with the dish operating well outside safety limits for the entire duration of the moonwalk. The Apollo 11 support was such a great success that Parkes was contracted four months later to track the Apollo 12 mission during its critical landing in the Ocean of Storms.

The following year, Parkes played a vital role in tracking the crippled Apollo 13 spacecraft. Parkes was not initially required for the mission since the extreme northerly declination of the Moon at the time of the planned moonwalk meant that it was only visible from Parkes for just a few hours a day. This was deemed to be insufficient to warrant its use. All this changed however, when just two days into the mission on 14 April 1970, one of the spacecraft's oxygen tanks exploded, severely crippling the Command Module, *Odyssey*.

John Bolton just happened to be in his office at the time, and was listening to the air-to-ground conversations when he heard the mission commander, Jim Lovell report; *"Houston, we have a problem"*. From his thorough understanding of the flight plan, John realised that the lunar module (LM) would be used as a life boat and that the immediate return to Earth would be in Parkes coverage time. He anticipated that Parkes would almost certainly be called in by NASA.

Luckily, CSIRO radio astronomers were present at the telescope conducting a special experiment at the time, so John Bolton was able to get them to quickly un-install their equipment and install the NASA equipment instead. As their equipment was brought down the ladder of one of the feed legs, the NASA gear was sent up in the lift on one of the other feed legs. Other equipment was flown to Parkes from the Radiophysics head office in Sydney. The observatory staff accomplished in just ten hours what normally took close to a week.

When the request for Parkes' support finally arrived from NASA, they were astonished to learn that Parkes was already aware of the problem and well on its way to being up and running for the next pass of the spacecraft. Parkes' senior receiver engineer, Dave Cooke, got the receiving equipment operating in time for Parkes to begin tracking Apollo 13. The extremely weak voice signals from the *Odyssey* were sent along landline to Sydney then onto Houston. The microwave links

The scene in the Parkes control room during the Apollo 13 mission. Bruce Window is hunched over the chart recorder and John Bolton is standing behind him. (Image Copyright: CSIRO)

that had been established for Apollo's 11 and 12 were not operational at this stage. Shortly afterward, engineers from Honeysuckle Creek and Tidbinbilla, headed by Bruce Window, arrived by chartered flight and landed in the field, right next to the telescope. Working all night, they were able to complete the set-up, while OTC and PMG technicians re-established the microwave links to Sydney before the next pass of the spacecraft. The critical nature of the Parkes support was evidenced by the fact that the feeble signals were a thousand times weaker than those received from Apollo 11.

Meanwhile, Mike Dinn, the Deputy Director in charge of Operations at Honeysuckle Creek, was co-ordinating the efforts of the Australian stations. At one point he had up to ten receivers tracking the spacecraft. Parkes' inclusion was critical at this stage, owing to unexpected interference from the Saturn IV-B third stage. On previous missions, the Saturn third stage, which boosted the spacecraft towards the Moon, was put on a course to orbit the Sun. With Apollo 13 however, its trajectory was altered so that it would follow the spacecraft closely and impact with the Moon in order to test the seismometer left months earlier on the Moon by Apollo 12. In order to track the progress of the SIV-B, a transmitter was installed within it that operated at the same frequency as the LM transmitter. It had always been the plan to switch on the LM transmitter only when it had reached the Moon, and after the Saturn third stage had impacted on the Moon, so there should have been no problems. Now however, with the astronauts using the LM as a life boat, the conflicting transmissions from the LM and the nearby SIV-B were interfering with each other. The smaller 26 metre antennas of the Manned Space Flight Network (MSFN) had beamwidths (fields-of-view) that were so large that they were unable to discriminate between the two, which caused problems with tracking and signal reception. Parkes however, with its larger size, was able to isolate the spacecraft within its narrower beamwidth. The vital signals were then passed on to Houston for analysis. Its greater sensitivity also meant that the Parkes telescope was able to downlink the telemetry data more quickly, thus saving precious time and spacecraft power. The 64 metre Goldstone dish was able to do the same in the non-Parkes coverage periods and the two together were able to extract the feeble but vital telemetry and save the mission from disaster.

As a gesture of goodwill and friendship between Australia and the Unites States, Sir Frederick White, chairman of the CSIRO, declared that the CSIRO would assume the full costs of bringing the Parkes telescope into commission to help Apollo 13.

John Bolton and his staff remained on site for the entire duration of the mission, going without sleep for long periods, ensuring all the telescope's systems were fully functional. Not until the astronauts were safely back on Earth did they relax. The combined Australian effort, and Parkes' involvement within it, is in many ways the Observatory's finest moment.

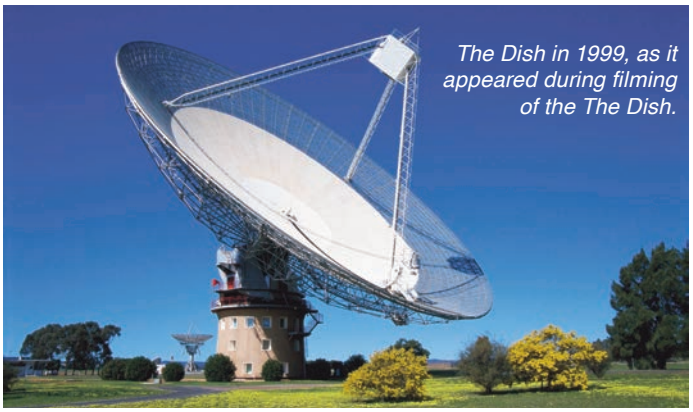
Huygens Heroes: On 14 January 2005, the Parkes telescope was tracking the ESA Huygens space probe as it descended through the atmosphere of Titan, Saturn's largest moon. The track was a resounding success and even managed to salvage one experiment from total failure. But it almost didn't happen.

Cassini/Huygens was launched in October 1997. The original plan had the spacecraft arriving at Saturn in July 2004 and shortly afterward, in November, the Huygens probe would detach from the Cassini mothercraft and descend through the atmosphere of Titan. But trouble struck from an unexpected quarter. In 2000, during the long cruise phase, a full-up test of the radio link between the two attached probes was performed and revealed a major problem with the spacecraft's communications decoder. A persistent Swedish ESA engineer, Boris Smeds, insisted that a proper test be conducted to pin down the problem. He found (to everyone's surprise) that the radio communications equipment contained a major flaw in its design that threatened the data reception of the Huygens probe as it descended through the atmosphere of Titan. Normally, radio equipment on board spacecraft is capable of shifting their frequency to cancel out any Doppler shift of the signal. Doppler shifts are the change in frequency as the source of the radio waves is moving away or toward the observer. Amazingly, Boris Smeds found that the Huygens receiver onboard Cassini could not track this shift in frequency and decode the data stream correctly. This would have resulted in the data being scrambled and rendered unusable. Fortunately, however the design flaw was found early enough for a solution to be devised during the long cruise to Saturn.

It was decided to alter the descent profile of the Huygens probe. Instead of occurring in November 2004, the descent would now occur a few months later in January. The probe would descend at a shallower angle and more perpendicular to the orbiting Cassini mothercraft passing overhead. The resultant Doppler shift as observed from Cassini would be much less than before and within the tolerances of the communications equipment. The data would not be scrambled and the mission would be saved.

Shortly after this solution was devised, it was realised that with the new descent profile the antennas onboard Huygens would be pointing just 30 degrees from the Earth during its descent. This meant that it would actually be possible to detect the Huygens signals directly from Earth, something that wasn't possible with the original descent profile. The Joint Institute for VLBI in Europe (JIVE) mounted a scientific case to observe the signals from Huygens. By combining several large radio telescopes around the globe to form a Very Long Baseline Interferometry network (VLBI), it was capable of pinpointing the probes position to within 1 km at Titan. By combining the results with simultaneous observations from the Cassini mothercraft, a three dimensional view of the winds in Titan's atmosphere could be determined as a function of altitude. Parkes was asked to be involved and the CSIRO's ATNF agreed. In fact, without the sensitivity of Parkes and the 100 metre Green Bank telescope in the USA, the experiment could not be possible. The Parkes telescope's receiving equipment was modified to allow reception of the Huygens signals that was outside the normal operating frequencies of the Observatory.

In late 2004, NASA/JPL asked if another secondary experiment could be piggybacked onto the JIVE sponsored VLBI observations at Parkes. This NASA experiment was dubbed the Doppler Wind Experiment (DWE) and once again the CSIRO's ATNF agreed. This experiment was designed to act as a backup to a similar experiment being performed on the Cassini mothercraft. As the Huygens probe descended, the Doppler shift of its signal would be measured to determine its velocity away or toward the mothercraft. Since any variation from the planned descent would be due to the little probe being blown about by the winds in Titan's atmosphere, this experiment would effectively be measuring the winds of Titan very accurately. Only two telescopes on Earth were equipped with this experiment — Parkes and Green Bank. From these two large telescopes the signal could be tracked in real-time thus providing immediate knowledge of the probe's descent. At Green Bank, the probe would be tracked until it set there twenty minutes before the probe's expected landing time. At Parkes however, the probe would rise four minutes before its scheduled landing time, that is, the critical



The Dish in 1999, as it appeared during filming of the The Dish.

observation of the probe's landing would occur right on the horizon of the Parkes telescope — yet again.

The atmosphere in the Parkes control room was palpable. Dr John Reynolds, the Officer-in-Charge of the Parkes telescope, had overall responsibility for the operations at Parkes. The entire CSIRO and NASA team at Parkes performed their duties magnificently. Parkes was able to track the probe's landing and announced its late, but safe, arrival to the waiting world. At ESA's mission control in Darmstadt, Germany, cheering erupted. Parkes continued tracking the probe on the surface of Titan until it finally set at Parkes three hours, later still transmitting strongly. The batteries had lasted far longer than expected. The champagne was duly popped open in celebration. Thankfully for this moon landing, the high winds were on Titan and not at Parkes.

Shortly after the track was completed and the data was being received from the mothercraft at NASA's DSN station at Tidbinbilla, it was realised that the data transmitted by one of Huygens' two transmitters was missing. It was this channel A transmitter that Parkes had been tracking so we knew it had functioned properly. The horrible realisation suddenly dawned on the mission controllers in Europe that the radio receiver onboard Cassini which was meant to receive the signals from Huygens' channel A transmitter was not switched on. Due to an error by controllers on Earth, the command to turn the receiver on was not sent. Fortunately, the second, channel B, receiver on Cassini was switched on, and it received the channel B transmissions from Huygens' second transmitter. Since the data was redundant, very little information transmitted by Huygens was actually lost. However, the DWE onboard Cassini depended on receiving the channel A signal. This was lost. Suddenly, the Parkes and Green Bank signals, which were initially only meant to be backups, assumed greater significance. The DWE was salvaged from total failure by using the Parkes and Green Bank data instead.

It's strange how serendipity plays a role in many of these events. If Boris Smeds had not identified the communications problem which subsequently allowed Parkes to be involved in the mission, the entire mission and the Doppler Wind Experiment would never have succeeded. In an interesting coincidence, in March 1986, Boris Smeds was stationed at Parkes to oversee the ESA communications links during the Giotto encounter with Halley's Comet.

The Dish: The pleasing aesthetics of the dish have inspired artists and film makers. Many films, documentaries and books have been produced about the telescope. In 1999, the feature film "The Dish" was shot at the Observatory. The film dramatised the events leading up to the momentous Apollo 11 support and was a major success in Australia. The film re-introduced Parkes to a new generation of Australians. A curious side-light was that during the televised Huygens press briefing by ESA on 15 January 2005, the Parkes telescope was introduced to the European audience as the telescope featured in the film, The Dish. It was gratifying to see how widely the film's reputation had spread.

Taffy Bowen, at the inauguration of the Parkes telescope in October 1961 said: *"... the search for truth is one of the noblest aims of mankind and there is nothing which adds to the glory of the human race or lends it such dignity as the urge to bring the vast complexity of the Universe within range of human understanding."*

Over the past 45 years, the astronomers of Parkes have reaped a rich scientific harvest from the fertile Goobang Valley. New discoveries continue to be made and the Parkes radio telescope continues its legacy of furthering our understanding of the Universe.

Parkes Control room during later Apollo missions. John Bolton is on the right seated at the computer console.

PLANISPHERE

A planisphere makes a great companion to our book. It is a hand-held aid used to identify which stars and constellations are visible on any particular date and time.

Designed for the Southern Hemisphere, the Night Sky planisphere is printed with dark stars on a light background for easy night time readability. The constellations are drawn simply, emphasizing the brighter stars. A selection of deep sky objects for binocular viewing is included.

The map scale is larger than on similar-size planispheres because the whole sky does not have to be shown on a single map. The Night Sky's design corrects for distortion of the constellations around the horizon, inherent on single sided planispheres. Its plastic construction makes for a durable and moisture resistant product.

To use this planisphere is easy. Just turn the disk so the date lines up with the time and it will show you what the sky looks like now. It's that simple!

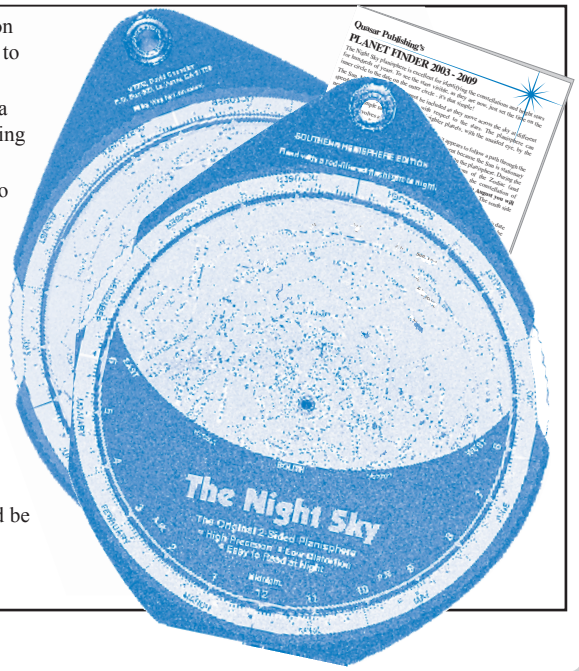
PLANET FINDER

Each planisphere comes in a reusable plastic sleeve and also with Quasar's Planet Finder card. This card includes information allowing you to easily locate the position of the five naked-eye planets on the planisphere.

These planispheres are available direct from Quasar Publishing. They come in two sizes: the large 22cm version is $24, the small 13cm one is $14, price includes postage within Australia. Payment can be by cheque, money order or credit card (VISA, MC or Bankcard). Orders should be sent to:

Quasar Publishing, PO Box 85, Georges Hall NSW 2198

Fax: (02) 8814 5331 or Email: sales@quasarastronomy.com.au



We Are All Beginners

So you are uneasy being a novice — we were all beginners sometime. One of the pleasures of astronomy is you don't need anything to enjoy the wonder of the night sky. Likewise, you don't need to know anything either. You already have the important part — the interest; the knowledge (including the jargon) will come when it is required. Have you ever listened to enthusiasts at flower shows expounding the virtues of their prize winning orchid? To a novice it can sound like they are speaking in Greek — amateur astronomy is no different and we do talk Greek (well the alphabet anyway). By the way, the flower people didn't learn their language overnight.

On this page we will concentrate on the virtues of naked-eye astronomy. Having some basic equipment will help. This book and a red light torch are a good start. The red light can be as simple as a piece of red cellophane wrapped around the end of the torch and secured with an elastic band. The red light is to help preserve your night vision when reading charts and books, just as it is used in submarines at night. Even if you are forced to observe under the light polluted skies of the suburbs, it is still important to eliminate direct lights in your eyes. If you have a neighbour with that annoying backyard light that seems to be always on, invite them over to enjoy the sky — they will soon get the message. Also don't underestimate the importance of being comfortable. A reclining chair and warm clothing is soon appreciated.

Perhaps a good place to start is to become familiar with the constellations. This is where the All Sky Charts (pp 70–79) or a planisphere can come in handy. A planisphere, a good companion to this yearbook, shows all of the sky, but not the Sun, Moon and planets because they move. The planisphere is useful by showing at a glance all of the constellations visible at the time you are observing. An example is shown on page 13. Once you start to look around the sky using a planisphere or the All Sky Maps you may be pleasantly surprised how easy it is to recognise some of the constellations. These star patterns will quickly become familiar and will soon be like old friends. Learning the sky under light polluted city skies is easier than under dark rural skies because there are fewer faint stars visible to confuse the patterns. When it comes to the minor constellations, like those in the far south such as Octans or Mensa, you will need binoculars or dark country skies to view them.

Once you have a working knowledge of the prominent stars the brighter planets can be much easier to recognise. Besides the Sun and Moon, five of the planets are easily seen with the naked-eye: Mercury, Venus, Mars, Jupiter and Saturn. Venus, the evening or morning star, is quickly recognised as it is by far the brightest 'star' in the sky. Jupiter is also easy to find, for only Sirius can rival its brilliance. Mercury, Mars and Saturn can be a little less obvious and this is where the Sky Views, in the monthly sections, can help.

The night sky regularly puts on displays for us called conjunctions. Since the planets, including Earth, are moving round the Sun, their positions change constantly with respect to the background stars. As seen in the sky, the planets seem to pass by each other and bright stars. When a planet is near another planet, the Moon or a star, it's called a conjunction. When the Moon is included, it can be a wonderful sight. The Sky View diagrams are designed to display the most spectacular conjunctions during the year. A good example is the one between the Moon, Mars and Saturn on May 31 (see Sky View p. 44). These objects all lie within a 10-degree circle in the northwestern evening sky. This is simply a chance alignment of these celestial bodies, they only look close together; in space they are still separated by enormous distances. When talking distances beyond the Earth, it is difficult to use normal scales such as kilometres because the numbers would be so large. Instead, let's use the time it takes for light to travel from these objects to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over one second to reach us, Mars 17.9 minutes and Saturn 80 minutes. If you include the open star cluster, M44, we are now out to 520 years (most commonly referred to as light years). Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, M44 is just in our neighbourhood. Light takes some 100,000 years to cross from one side of the Milky Way to the other!

While on the subject of naked-eye Solar System objects, there are three other challenges. The planet Uranus can be glimpsed under ideal dark skies, but you will need a finder chart (p. 126). The All Sky Maps (map 8) will show you where in the sky the field of the finder chart can be found. Also, Jupiter's satellite Callisto and the minor planet Vesta can be sighted under the right conditions (see discussion on page 27).

The following events are ideal for naked-eye observations;

- Meteor showers (which are described in Part I)
- Observing artificial satellites. These can be fun to look for up to a couple of hours before sunrise or after sunset (the Heavens Above website will give you tailored predictions for your latitude and longitude).
- Aurorae, if you live far enough south (see page 8)
- The phases of the Moon. Don't forget that the Moon can be followed into the daytime sky. For a brief period (up to 3 days) either side of a New Moon, it can be difficult to see in the daylight.

While talking daytime viewing, if a Sky View shows Venus very close to the Moon in the early evening, try finding the planet in the daytime sky late in the afternoon. Venus is bright enough to see in broad daylight, provided it is not too close to the Sun. The challenge is knowing where to look in the featureless daytime sky and getting your eyes focused correctly. Having the Moon nearby helps in both these areas.

The next step is to get out under dark country skies, preferably when the Moon is not around. Now we begin to see naked-eye deep sky objects. The autumn / winter evening skies give us in the Southern Hemisphere a magnificent view of our home galaxy, the Milky Way. It is amazing the detail that can be seen with the unaided eye, such as the bright central bulge around Sagittarius and the numerous dark lanes running along its length. Have a look for the Aboriginal 'emu' constellation. The head is the dark nebula, the Coal Sack, near the Southern Cross (complete with its faint 6th magnitude 'eye' star, see photo p. 59). The neck is the dark regions running through Centaurus towards Scorpius and the body is the complex of dark lanes in the region of the galactic bulge. It is best seen sitting on the southwestern horizon in the early evening autumn sky. The dark lanes in the Milky Way are clouds of gas and dust silhouetted against the bright galactic carpet of stars.

The list of naked-eye galaxies doesn't stop here. The Clouds of Magellan (Large and Small) can be seen appearing like small detached sections of the Milky Way, in the far south. In the north we have M31, the Great Galaxy in Andromeda. There are also a number of open star clusters (such as M44 and M45) visible. When you see the obvious fuzzy patch we know as the globular cluster Omega (ω) Centauri, it can leave you wondering how it got a normal star name. There are a number of other naked-eye objects and the All Sky Maps will help you identify these.

A final word of warning. By purchasing this book you may have started on a lifetime of frustration at the weather and having to train your family to organise events so they don't clash with New Moon weekends. The uncertainty of the weather can even add spice to the hobby. To pull up your car, having driven through rain for the last hour, to see a magnificent winter's evening sky with the Milky Way stretching from horizon to horizon can be a fantastic adrenalin rush. Enjoy the buzz.

Photograph of a three planet conjunction by Cass Alexander, Rushworth Observatory. June 25, 2005 at 6:30pm EST.

A Word About Binoculars

Probably the most cost-effective accessory for the beginner are binoculars. A reasonable quality pair can be purchased for the same cost as a cheap, low-quality telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a low cost way of gauging their level of dedication. This does not mean we are suggesting the quality of the binoculars should be poor. It is recommended that binoculars should be purchased from a reputable optics or telescope dealer. These people appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. To observe details on the Moon or look for Jupiter's moons, it is recommended that binoculars are not hand held. Sometimes you can brace yourself on the arms of a chair or the roof of a car. This can be important if the power of the binoculars is more than 10X. A power of 7X is a reasonable compromise. It can give a good field of view with adequate magnification to glimpse some of the moons of Jupiter. The size of the aperture normally comes down to what is comfortable for the person to handhold and the budget. 7 X 50 binoculars (7 times magnification, 50mm diameter front lens) are fairly popular with amateurs. Telescope dealers can also assist with mounts to hold the binoculars steady. These are often brackets designed to attach them to a camera tripod (sorry, another possible expense).

For the novice, finding your way around the sky is far easier with binoculars than with a telescope. A telescope is a bit like looking at the sky through a straw and that view is usually upside down and sometimes mirror-imaged! Even when using a low power in a typical amateur telescope, the field of view is only about a degree. A pair of 7 X 50 binoculars can give a field of about 7 degrees in diameter, or if you like 40 to 50 times the area visible through a small telescope. It is not unusual for the general public to ask when looking through a telescope, "where in the sky is that?" for looking at the star field doesn't make the location obvious. Some low-powered binoculars will fit the main stars of the Southern Cross in the same field, giving you a feeling of knowing where you are and in control. The field size is normally marked on the binoculars.

Even with binoculars you still need to practice pointing the instrument. There is a tendency to look too low, so if you don't see what you are after, the first thing to try is to tilt the binoculars up. A technique that may help is to find an obvious nearby bright star, or better still, a bright star pattern (sometimes called an asterism, see page 59) and star hop across. If your object isn't too high in the sky you can try finding something on the horizon directly under it, like a distinctive tree outline, and move the binoculars up. Another method that might take a little getting used to is to stare intently at the area of the sky with your unaided eyes and then moving the binoculars into place without moving your eyes. Practice on bright stars first until you are comfortable. Talking of comfort, plan your observing, for it could be very difficult to look directly up (at the zenith), especially if the binoculars are mounted on a tripod. This is where sitting back in a reclining chair and hand holding the binoculars makes it easier. Also, it is worth remembering that a pair of binoculars is prone to dewing just like a refracting telescope. A couple of cardboard tubes on the front, sticking out about 75mm, can prevent dew and also help eliminate stray light. If you do strike dew, warm air from a portable (12V) hair dryer, blown gently across the lens, is the safest way to fix the problem and be back observing a few minutes later.

Taking your binoculars out under dark country skies at some stage is a must. It has been said that one of the joys of the Milky Way's satellite galaxies, the Magellanic Clouds, is that they show as much detail through a moderate size amateur telescope as that seen by large professional telescopes looking at distant galaxies (outside our Local Group). This argument can be extended to our own Milky Way, but in this case a humble pair of binoculars is sufficient. The wide field of binoculars is ideal to show detail in the complex dark lanes and star clouds running through our galaxy, especially around the central galactic bulge region in Sagittarius. Some of these dark rifts and star cluster regions are sometimes barely visible to the unaided eye, but quite obvious through binoculars. Their wide fields can also show some larger open star clusters such as the Beehive (M44) and the Pleiades (M45) better than they look through the narrow field of view of a telescope.

Buying your First Telescope.

There will come a time when you will want to take the plunge and buy a scope. Obviously you can only go so far with binoculars and the chance of seeing the Universe up close, live and personal has to be experienced. Those of you who have read our yearbooks in the past will be sick of hearing this advice, but it is still very true. Don't buy anything without spending some time evaluating the various telescopes available — establishing what suits you best. This is where your local astronomical society can be a gold mine of information (see Part III, page 149). These people are more than willing to show off their scopes and discuss the various features available and their associated pros and cons. Learn from these experts. If you can look through the instruments under light polluted conditions as well as in dark, country skies, all the better. This gives you a realistic feel of what to expect. The telescope shops and public observatories also have many years of experience in this area — draw on their advice as well.

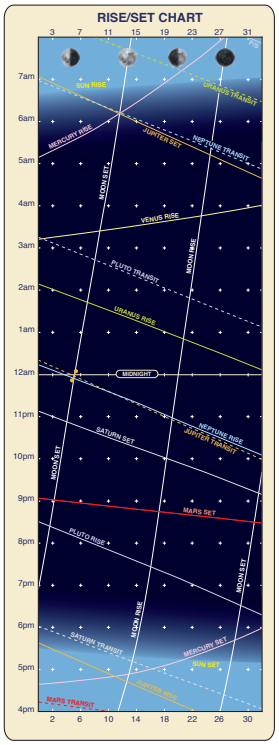
There are a multitude of uses for binoculars in amateur astronomy. Some of these include:

- Helping to find stars and planets in a bright twilight sky.
- Looking at the larger craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views, All Sky Maps and finder charts in this publication. This can be important in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Contrast the yellow of Alpha Centauri with the blue of Beta Centauri.
- The crescent phases of Venus.
- Stars and planets close to the horizon.
- Looking at artificial satellites in the early evening sky. You might find them with the naked-eye, but binoculars will help you see them sometimes vary in brightness as they tumble, and allow you to follow them further into the Earth's shadow before disappearing.
- Monitoring the change in magnitude of some of the brighter variable stars. There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society (p. 149).
- Looking at wide double stars.
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on p. 114). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites as the moon passes into or out of the shadow of the planet. The magnification of the binoculars will dictate how close to Jupiter you can see such an event.
- Lunar occultations of some of the brighter stars (see also Part II, p. 94). Small binoculars are well suited for magnitude 4 or brighter events, preferably on a dark limb. There is no reason why you should not time the event as described on page 94.
- Looking for bright comets (from dark skies).
- Some of the bright deep sky objects such as star clusters, Milky Way regions, and the Magellanic Clouds. The galaxies M33 in Triangulum and NGC 253 in Sculptor are worth going after with binoculars.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart to see which 'star' has moved. Taking the co-ordinates of a minor planet from Part II, page 128, and plotting that position on the All Sky Maps, will help you find the correct area.
- Searching out Uranus and Neptune, using the finder charts, see page 126 and All Sky Map 8.

A lot of the above can be done from a typical suburban backyard. It is not always necessary to drive for hours to reach dark skies.

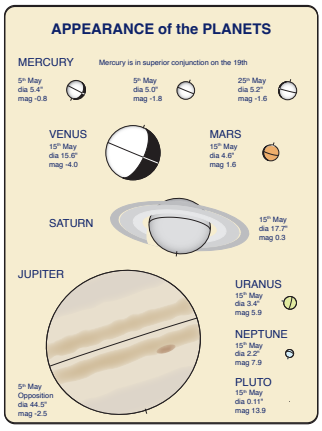
How Do I Use This Book To Plan My Observing?

This publication was never intended to be read from cover to cover (but we don't mind if you do!). It is a reference work, which, if you look closely enough, gives you a number of pieces of the picture. Also, the picture is quite different depending on whether you are using your eyes, binoculars, or a telescope. The data that an astrophotographer would find useful could again differ. To illustrate how to use this book we will work through an example.



You live near Melbourne, Victoria, and are planning to go out and observe on the evening of May 4 and hoping to push on all night. Being in an eastern state, you will use times in EST, when given. A good place to start is the Visibility of the Planets chart (p. 20). Looking around early May, the diagram is showing Venus, Mercury, Uranus and Neptune in the morning sky, with Jupiter, Saturn and Mars in the evening. Jupiter is close to the midnight line so you would expect it to be close to opposition and visible most of the night (in fact, it is at opposition on this evening). A quick check of the Rise/Set Chart for May (p. 38) confirms Jupiter rising close to sunset. On this same diagram, we see the Moon setting just before 11pm, around the same time as Saturn sets. This tends to indicate a conjunction and possibly there may be a Sky View — which there is, see 'May 3 to 7' on page 41. We see the near First Quarter Moon located around 5 degrees below Saturn in the northern evening sky in Cancer. The Rise/Set diagram shows Mars to be the first planet to be lost on this evening, setting around 9pm. However, the Appearance of the Planets diagram (p. 38) shows a quite small image of only 4.6 arc seconds. It is coming off its opposition in late 2005 and unfortunately will continue to decline for the rest of the year (see Planetary Angular Size diagram on page 81). With the Moon near First Quarter, it presents a great image in even the smallest telescope. A look at the occultation tables for Melbourne shows a 6.4 magnitude star, ZC 1279, disappearing behind the Moon's dark limb at 8:02pm.

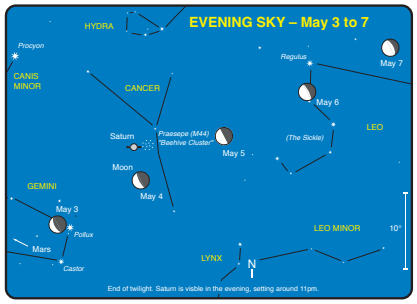
While talking about observing in a small telescope, Saturn's rings are well worth a look, with the planet casting an obvious shadow on the rings. When you can pull yourself away from this sight, its brightest satellite Titan should be fairly easy to find. Looking at table 2, on page 121, we see Titan is about one day away from a maximum elongation (date is May 5.308 UT). Looking at the Apparent Orbits diagram, Titan would be around the 15-day mark, due east of Saturn, very close to its maximum elongation. Being east of the planet, it would follow Saturn out of the field of view of a telescope that isn't tracking. Saturn, even through a small telescope, displays a sprinkling of satellites with five of the moons brighter than 12th magnitude. The same pages that helped in finding Titan explain how to calculate the relative positions and hence identify these fainter moons as well.



While waiting for the morning planets, Jupiter will be well placed high in the late evening northern sky; being at opposition, it transits the meridian (due north) at midnight. It is worthwhile checking to see if there are any Jovian satellite events tonight. The table on page 112 shows we can see a complete eclipse of the inner moon, Io. It disappears (passes into the shadow of Jupiter) at 10:29pm EST (22:29) and reappears a little over 2 hours later at 12:39am (00:39) on the morning of the 5th. The Jupiter's Moons diagram on page 114, shows this event and satellites II (Europa) and III (Ganymede) can be seen close together, passing each other during the night on the western side of Jupiter. On the eastern side of the planet will be the outer most Galilean moon Callisto (IV) which is a day past maximum elongation. In fact it might be possible to glimpse Callisto with the naked-eye when applying the correct technique — see page 27 for more details.

While on the subject of Jupiter, you might wonder what the chances are of glimpsing the Great Red Spot (GRS) tonight? The longitude of central meridian for the GRS is now around 103°, using the System II data (see page 117). It is generally considered observable up to one hour either side of this time which translates to a longitude range of 67° to 139°. A calculation for System II at 10pm on the 4th (12hr UT) shows the central meridian as 91°. It looks like the GRS will soon transit the central meridian (around 10:20pm) and it is worthwhile observing from around 9pm to watch it transit the central meridian over the next couple of hours.

We are possibly in for a real treat this evening — a comet bright enough to see in binoculars and possibly naked-eye (assuming you have escaped the light polluted suburban skies). The C fragment of Comet 73P/Schwassmann-Wachmann 3 (SW3) is predicted to be around 4th magnitude at this time. See the ephemeris on page 132. Although we don't have a position for May 4 there are positions for April 29 and May 6. We can mark these on the All Sky Map No. 7. A simple interpolation puts the comet around the star Pi Herculis (a couple of degrees above). This same exercise can be done with the 7th magnitude B fragment of SW3, which places it 2 to 3 degrees west of Eta (η) Herculis (below and to the west of the C fragment by about 8°). An approximate position can also be determined on the wide-field finder chart on page 39, which should be adequate if these fragments become as bright as predicted. A planisphere shows Hercules rising around 10pm and with the Moon gone by 11pm both fragments should be well placed in the northern sky by the early morning. See also the monthly section description on page 40 and the history behind this comet on page 130. The only other comet that is expected to be at least 10th magnitude on this evening is C/2004 B1 (LINEAR). The comet is probably at its brightest in May and repeating the exercise with the coordinates and the All Sky Maps (No. 9 this time), we find the comet in Aquila, approximately 2 to 3 degrees southeast of Delta (δ) Aquilae. It is rising in the late evening and will be well placed to observe by mid-morning in the northern sky.



Neptune is rising around midnight, with Uranus two hours later. If you have a large enough telescope (minimum 20cm) you might enjoy the challenge of working out the approximate positions and observing their moons (see page 123). But beware their brightest satellites, Titania (Uranus) and Triton (Neptune), are only 13.5 magnitude. Taking Triton as an example, the morning of the 5th at 3am is May 4.708 UT, which is approximately 1.84 days before its next maximum elongation east, May 6.550 UT (Table 2). This places the moon around the 4-day mark on the Neptune diagram, northwest of the planet.

Nobody could miss Venus as it rises around 3am (see Rise/Set Chart page 38). At magnitude –4 it will be the brilliant star-like object in the eastern sky. Mercury will be less obvious, but well placed to observe as it rises around 5:30am, just after the start of dawn. The Appearance Diagram (p. 38), shows both planets to be gibbous but quite small. Venus, at around 15 arc seconds, is well down on its close to one arc minute maximum during inferior conjunction in January. Mercury is also diminished in size as it heads towards superior conjunction (its furthest distance from the Earth) on the 19th.

Don't forget to have a break occasionally and sit back and enjoy the view. There could be a bonus in the morning with the eta-Aquarid meteor shower being active (see page 40). It is supposed to peak now, on the 5th, and is best observed a few hours before dawn.

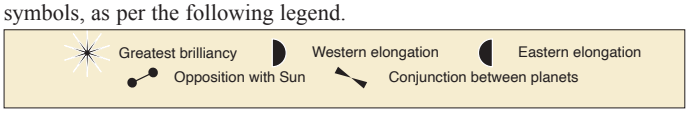
These are just a few examples of the way to apply the information in this book and how it can be a lot of fun planning an observing session.

The Monthly Sections

Each monthly chapter in Part I contains the following:

Rise/Set Chart

This will enable the reader to quickly determine when (or if) a planet or the Moon is visible in the night sky for any day in that month. Each chart has the midnight line centred, with the evening sky below this line and the following morning sky above. The two bands of lighter shading show the times of morning and evening astronomical twilight. The ideal time to observe an outer planet is at the time of transit (represented by dashed lines), which is when it is due north and has reached its maximum altitude. Also a number of events during the year have been shown using symbols, as per the following legend.



These charts only give an approximate local standard time and you will see from the specific rise/set times in Part II that there is variation from city to city. This reflects the effects of your position relative to the standard meridian and differing latitudes, as well as an object's declination. If more accurate rise/set times are required, see the tables for the object of interest in Part II. You can also adjust for rural locations using the appendix on page 139.

Highlights

This lists a few of the more interesting events during the month.

Appearance Of The Planets

This diagram provides the reader with a telescopic drawing of each planet drawn to the same scale. Under each image are the date, the planet's angular diameter and magnitude. Phases are also shown for Mercury, Venus and Mars. Each planet is presented with north to the top.

The Moon

This provides information on major events relating to the Moon. The data include the Moon's phases, apogee, perigee, occultations of planets or bright stars and lunar and solar eclipses. An event does not have to be visible from Australia to be included. The description will normally indicate whether or not it can be seen.

The Planets

Presented are general notes on each planet. Emphasis is placed on their suitability for observation and any interesting conjunctions and patterns between the Moon, other planets and bright stars.

Minor Planets (or Asteroids)

This section deals with the brightest asteroids that reach opposition this year (approximately 11th magnitude or brighter). An entry includes the date of opposition (when it is brightest), its magnitude and the constellation the asteroid is in at the time of opposition. Ephemerides for the brightest minor planets are included in Part II.

Comets

This section deals with the comets expected to be visible during the year. It points out those that are observable during the month and includes any interesting conjunctions. Note, with the possible exception of the 2 fragments of Comet Schwassmann-Wachmann 3, the known comets this year are relatively faint and will need a telescope. It is likely that many other comets will be discovered during the year, so who knows what surprises are ahead!

Meteor Showers

On any clear night we can sometimes see up to five shooting stars per hour. These are known as random or sporadic meteors. There are also annual showers, which return at the same time each year. Each shower seems to radiate from a focal point in the sky and is named after the constellation or a bright star the radiant lies near. For example, the radiant for the Leonids lies within the constellation of Leo. The monthly section lists the major showers that are suitable for observation — those largely unaffected by moonlight during their peak period. Information for all the known showers is given in Part II. It takes great patience to watch for meteors, but the occasional fireball makes it all worthwhile. It is best to do your searching on moonless nights, away from light polluted cities. As a general rule, more meteors are seen after midnight.

Diary Of Events

This is a list of all general phenomena associated with the planets and Moon. The presentation is keyed to those people who would like to know 'what's happening tonight (astronomically speaking)?' Included are:

- Phase of the Moon
- Key events in a planet's orbit
- Selected conjunctions between the Sun, Moon, planets, comets, minor planets (asteroids), brighter stars and deep sky objects

WHAT TIME IS IT?

Unless a time zone or a location is specifically mentioned, times given in the Monthly Section will be approximate local standard time. There are no adjustments made for Daylight Saving (or Summer Time) anywhere in this book. When Daylight Saving is in force you will need to add one hour to times given here. For example, any rise/set time from the charts will need to have one hour added to get daylight saving time.

When specific times are referred to in Part I they can be Eastern Standard Time (EST) or Western Standard Time (WST). They are the mean solar time on the meridian of longitudes of 150° E and 120° E respectively. For Central Standard Time (CST) subtract 30 minutes from the EST times given. Any times specifically given for Darwin or Adelaide are CST.

Queensland, NSW, ACT, Victoria and Tasmania use EST as their time zone. South Australia and the Northern Territory use CST and Western Australia uses WST.

SOME ASTRONOMICAL TERMS TO GET YOU STARTED

There are several astronomical terms you'll come across in Astronomy 2006, many of which are defined in the glossary at the end of the book. Here are a few of the more common ones, just to get you started.

Planet. Just like the Earth! A planet is a sphere of either rock or gas that orbits the Sun or another star. There are nine planets in our Solar System. The diagram on page 21 gives a good overview. The Moon and all the planets we see in the sky do not glow in their own right. They are only visible because of reflected sunlight.

Minor Planet. These are minor 'rocky' bodies in the Solar System that vary from a few to hundreds of kilometres in diameter. There are hundreds of thousands of minor planets, mostly in the main belt, between the orbits of Mars and Jupiter.

Star. Just like the Sun. Stars are enormous spheres of glowing gas that give off tremendous amounts of light and heat. They shine by their own light caused by nuclear reactions going on deep inside them.

Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'magn.'). The numbers work backwards. The faintest star you're likely to see with the naked-eye is about 6.0 magnitude (under country skies), while the brightest stars are –1.0 magnitude. Planets can be much brighter. Venus, for example, can be as bright as –4.0 magnitude, the Full Moon, –12 magnitude!

Waxing, waning, gibbous and crescent. The Moon is considered waxing between New and Full, after this time it is said to be waning. The Moon is gibbous when more than half is illuminated i.e., from after First Quarter to just before Last Quarter. On either side of New Moon, when less than half is lit it is a crescent. Gibbous and crescent are also sometimes used to describe the appearance of Mercury or Venus. Mars can also be gibbous.

Angles in the sky are measured in degrees. You'll see that the Sky Views have a line showing what an angle of 10° looks like on the scale of these drawings. On the back cover is a scale that can help you measure angles.

Twilight does not really end until the Sun is 18° below the horizon; this is called astronomical twilight. This happens about 90 minutes after sunset (or before sunrise) but it does vary with latitude. Only when astronomical twilight has ended is the sky considered truly dark. There is also civil and nautical twilight, see the glossary.

Culmination. When an object culminates it has reached its highest point in the sky and is generally considered to be the best time to observe it. For the planets, this is normally when they are due north or crossing the meridian.

Conjunctions. Differences will be often found between the separation distances (and times quoted) and those found in the remainder of Part I. Conjunctions involving only the bright stars, the planets and the Moon are geocentric. This is how they would look from a position corresponding to the centre of the Earth. The times and separations given in the text or Sky Views are the best as seen from Australia. Sometimes a lunar conjunction is followed by "Occn." This indicates that from somewhere in the world the object will be occulted (covered) by the Moon. The distance given is measured from the centre of the Moon (remember, the Moon has a diameter of 0.5°). Occultations involving the planets or the brightest stars are also mentioned in the 'Moon' text.

Abbreviations. These include:

- G is galaxy (SG spiral, IG irregular, EG elliptical, LG lenticular)
- OC represents an open cluster
- GC is a globular cluster
- DS is a double star
- N is nebula (PN planetary, BN bright and DN dark nebula)
- m.p. refers to a minor planet

There are also some astronomical catalogues including:

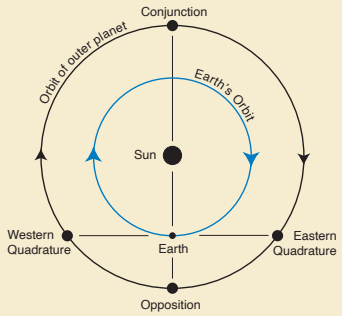
- NGC — New General Catalogue
- IC — Index Catalogue
- M — Messier catalogue

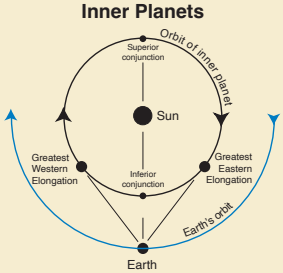
Time. When times are given, both EST and WST are presented. As these times are rounded to the nearest hour, it is unnecessary to include a separate entry for CST seeing there is only a 30-minute difference to EST. The remaining entries are less time sensitive and either have no time (i.e., closest day) or a PM or AM designation for an evening or morning event respectively. For 'timed' events that occur in the very early hours (before 2am) for EST, the WST conversion (subtracting 2 hours) takes it into the previous day — shown as 'prev. day'.

Feature Article

This section concentrates on some topics in popular astronomy. It can include observation, history, profiles of astronomy enthusiasts, astronomical equipment and techniques. Some of these are written specifically for beginners.

ORBITAL ASPECTS





A **conjunction** of a planet and the Sun is when they are closest together in the sky (not the best time to observe the planet). When an inner planet is between us and the Sun it is said to be at inferior conjunction; when on the far side of the Sun we have a superior conjunction. It is also common to hear this word referring to any two or more objects when they are closest to each other in the sky, i.e., at their minimum angular separation.

Opposition refers to the time a planet is opposite the Sun in the sky. An object in opposition will rise around sunset and will be visible the entire night (like the Full Moon). The inner planets, Mercury and Venus, can never reach opposition. Their orbits are both inside Earth's. We need to pass between an object and the Sun for opposition to occur.

Elongation is often used in reference to the inner planets and their greatest angular distance from the Sun, that is greatest western elongation (in the eastern morning sky just before sunrise) and eastern elongation (a western evening sky object just after sunset). This is generally the best time to observe Mercury and Venus.

Sky Views

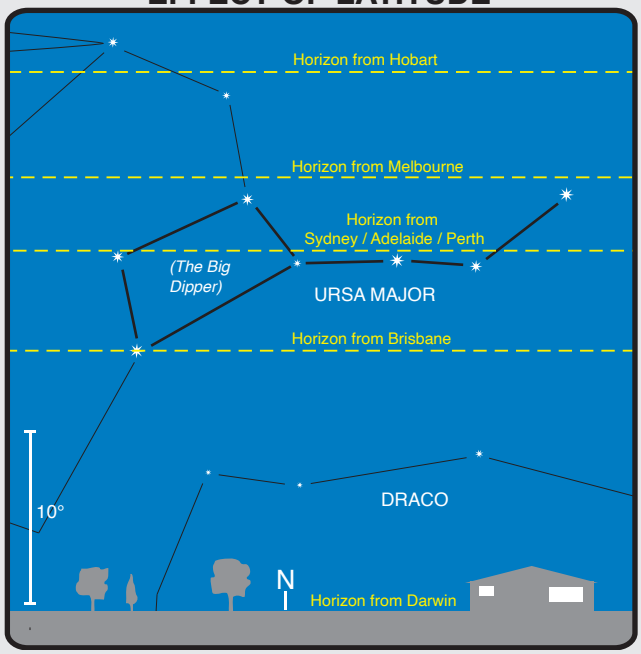
These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although, astronomically speaking, this would still be considered twilight, this is sometimes necessary to catch a glimpse of the planets when they are close to the Sun. This is especially needed for Mercury, because it never wanders more than 28° from the Sun. Sky Views which show a twilight view after sunset are called Evening Twilight and morning twilights are Dawn Sky. Those before midnight are Evening Sky and after midnight, Morning Sky.

The Sky Views (see also the legend below) include:

- The Moon (showing approximate phase) and the planets visible with the naked-eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies (down to approximately 5.5 magnitude). A prefix of 'N' means the object is in the New General Catalogue (NGC), an 'I' is the Index Catalogue (IC) and 'M' is a number in the Messier catalogue.
- Constellations are labelled (capital letters) and have black lines joining key stars.

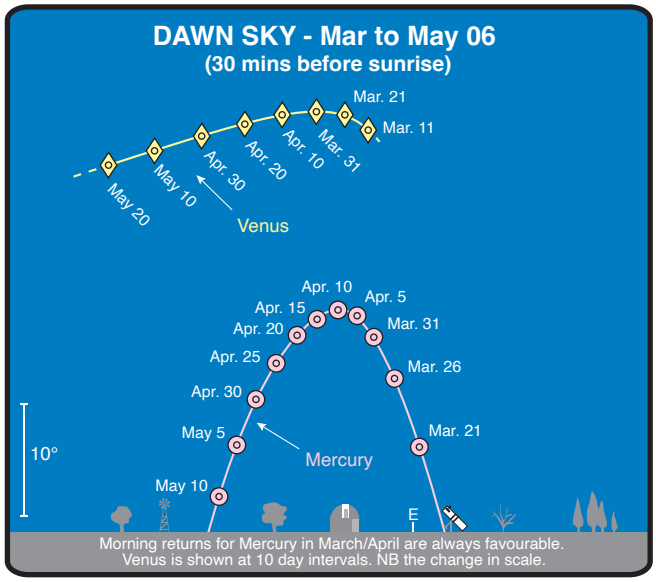
Uranus, Neptune and Pluto have been excluded from the Sky Views, as they are not generally visible to the naked-eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. In any case, because of the many faint stars of similar brightness close-by, separate finder charts would be needed to identify these outer worlds. These are on pages 126–127.

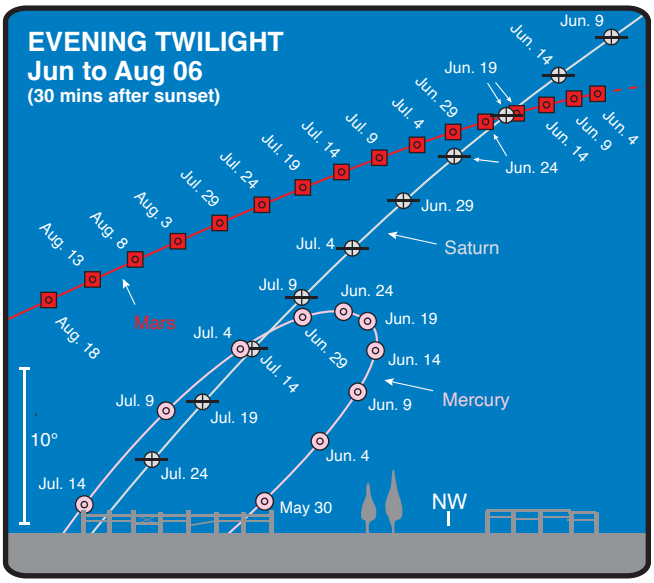
EFFECT OF LATITUDE

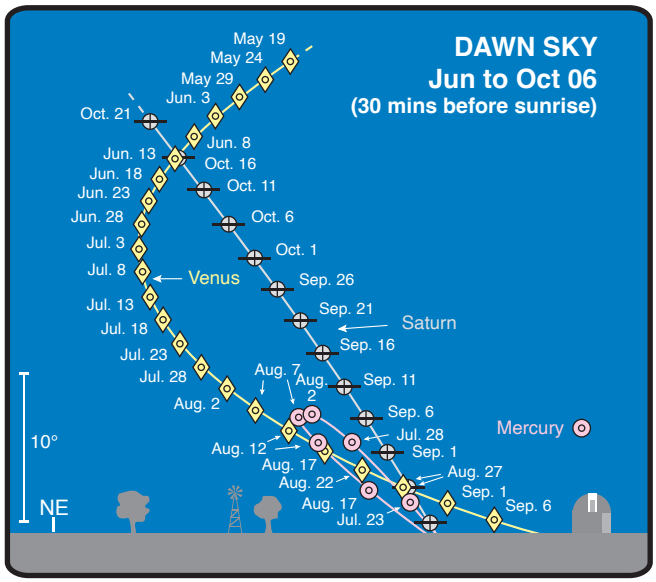


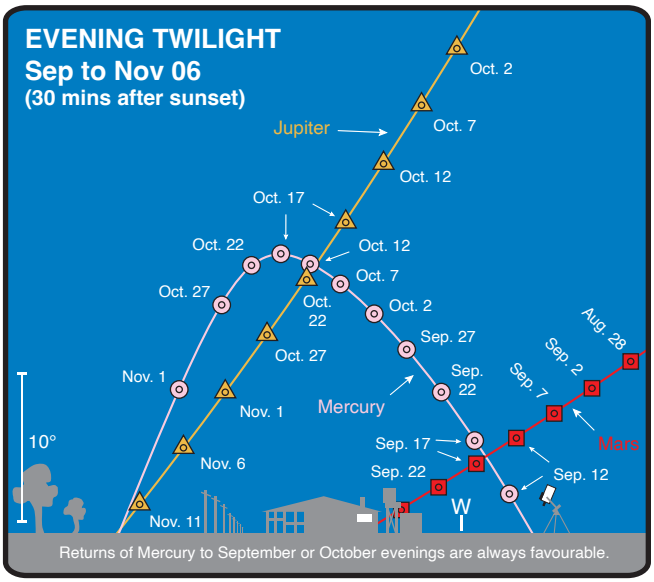
The Sky Views (see the monthly sections) have been drawn for a latitude of approximately 33° south of the equator. This is reasonably central for the population distribution of Australia. However, we live in a large continent which covers a wide range of latitude. The further you go north the more stars you see familiar to our Northern Hemisphere friends. As an example, let's take the Big Dipper. You may have first heard about this in books written in England or America. This group of stars is part of a larger group known as the constellation Ursa Major, the Great Bear. From Darwin the group is clearly visible above the horizon (but upside down). However, from the southern states not all of it is visible. The Big Dipper is best placed in the northern sky in mid-May around 9 pm (mid-June, 7 pm). Also from the south we see very little of the constellation Draco. The diagram is drawn to the same scale as a Sky View.

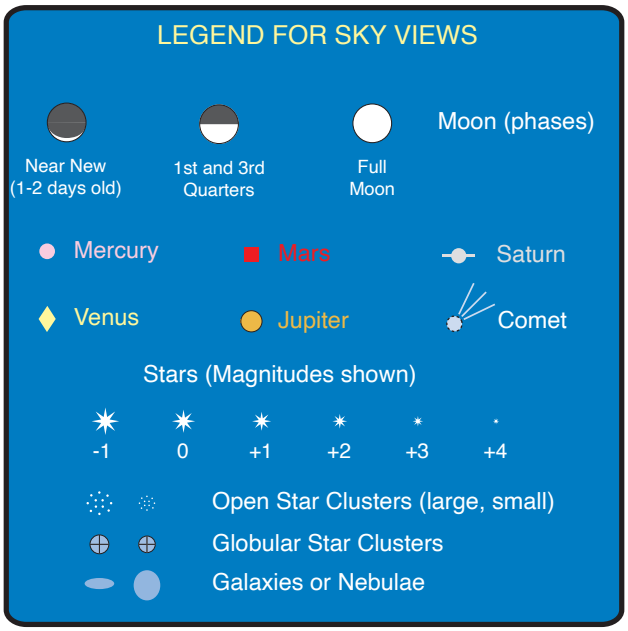
MOVEMENT OF THE PLANETS

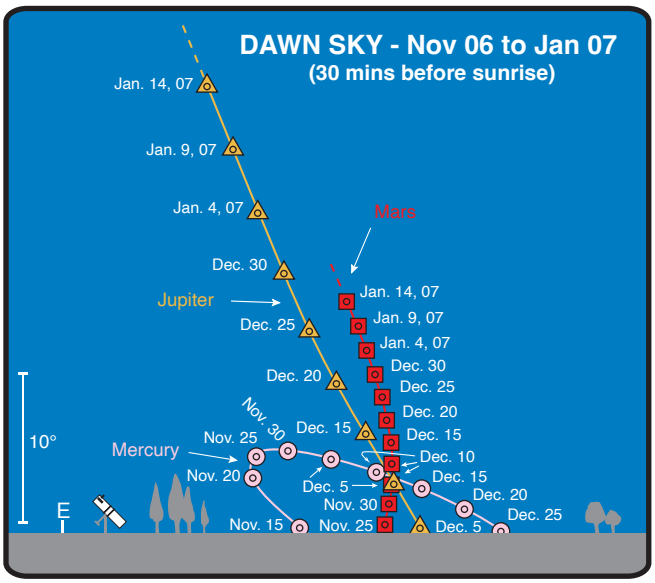






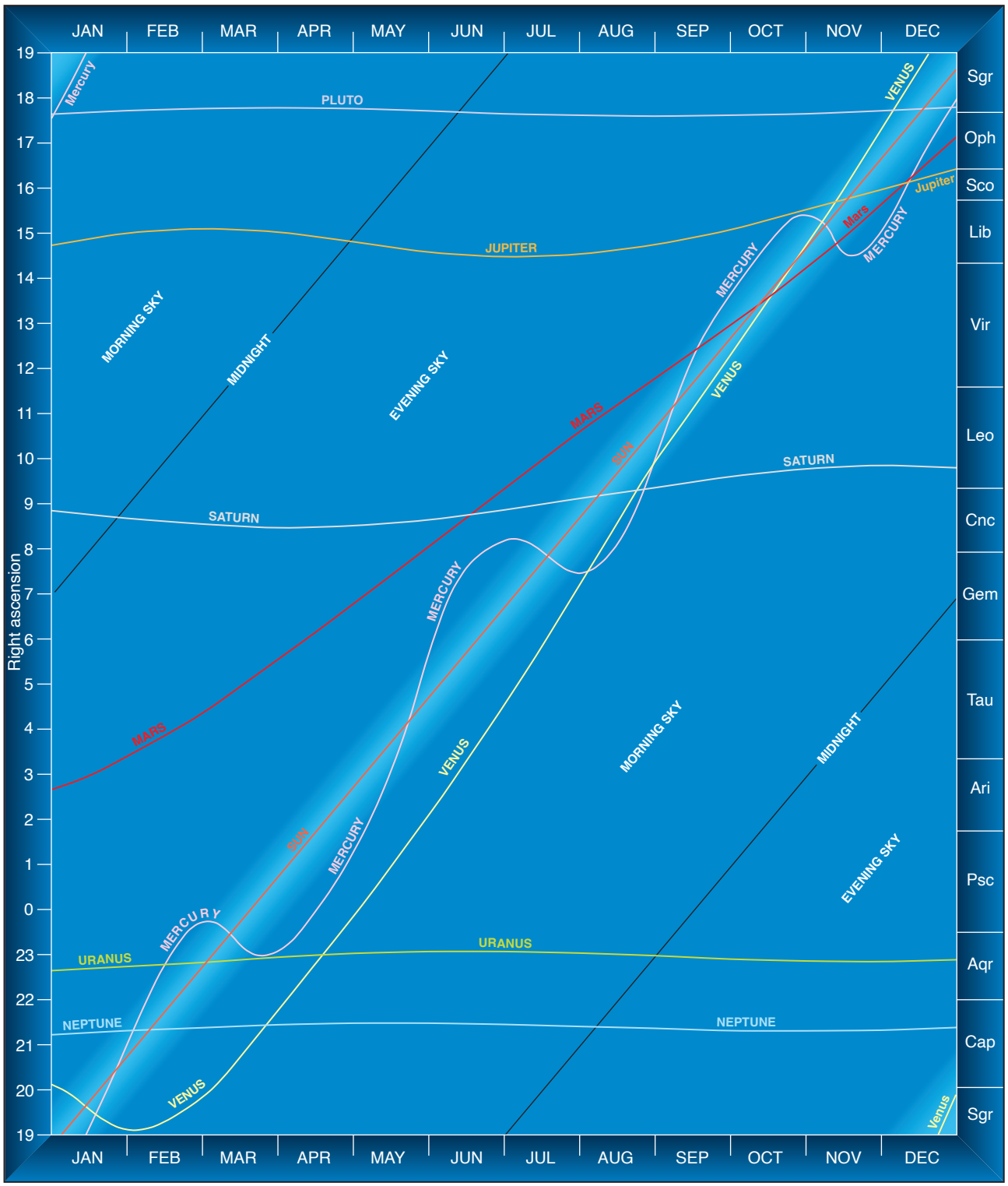






These diagrams are designed to help observers know when a planet first becomes observable after being in conjunction with the Sun, or is about to go into conjunction with our star. They are particularly useful as an observing guide for Mercury. Also, the Visibility of the Planets diagram (p. 20), allows you to see at a glance whether an object is in the morning or evening sky.

VISIBILITY of the PLANETS



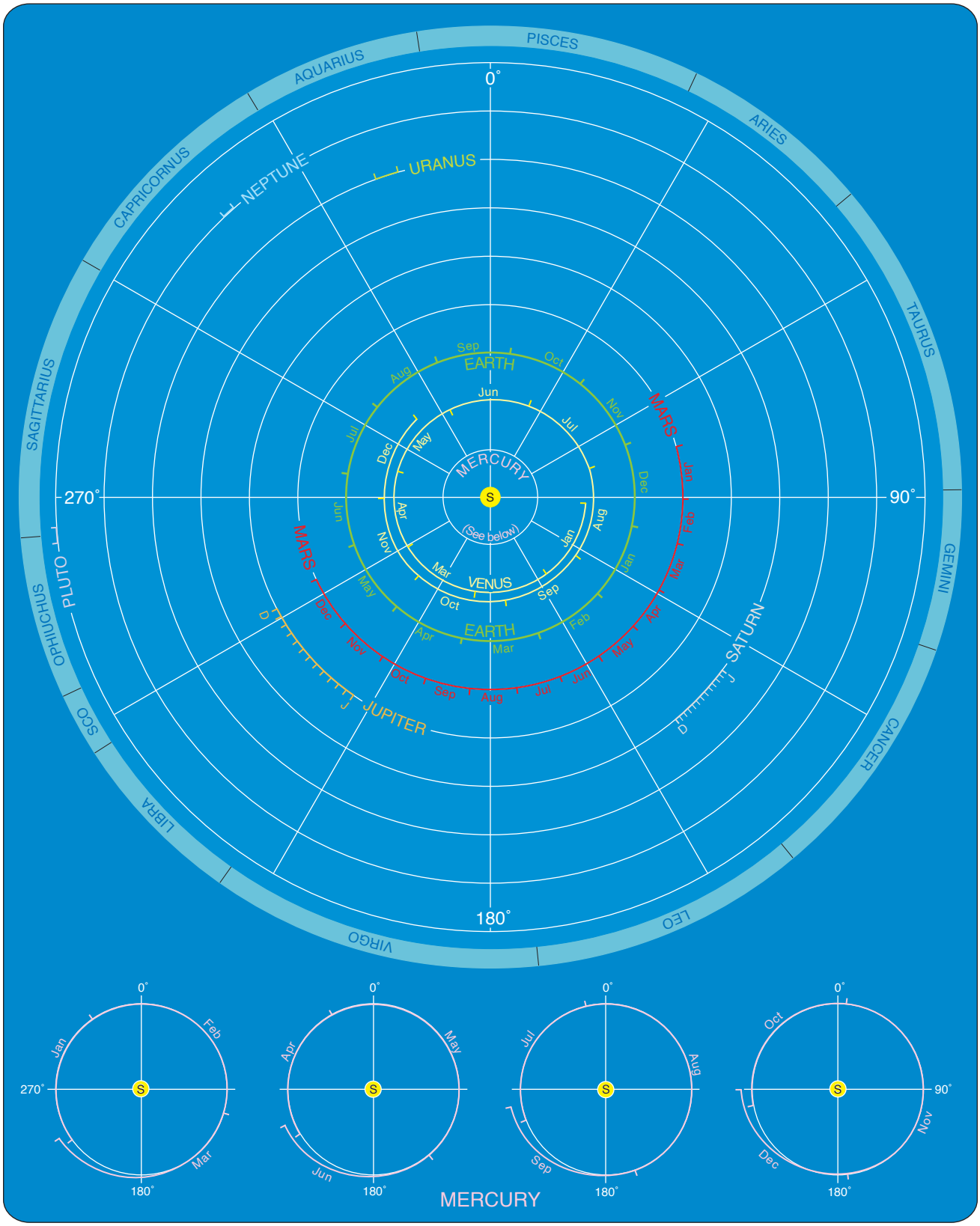
This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point, a horizontal line to the right vertical axis will show which constellation the planet is in (Saturn, from early September to year's end is visible in the morning sky in Leo).

Mercury and Venus are in either inferior or superior conjunction when they cross the Sun line, and at their greatest elongation when furthest from it. The best time to observe these inner planets is when their path extends beyond the twilight. For Mercury, the observing period in the evening sky are the months of February, June and late September/October, and in the mornings, mid-March/April, August and November/December. Venus is a morning object for the greater part of the year.

When an outer planet crosses the midnight line, it is at opposition and is visible the entire night, and when crossing the Sun line it is in conjunction. Where an outer planet's line shows a downward slope, it is in retrograde motion.

The diagram also shows when conjunctions between the planets occur. When two or more lines cross, the planets will be close together in the sky. This year's rare triple planetary grouping of Mercury, Mars and Jupiter is clearly shown where their paths cross in the December evening sky.

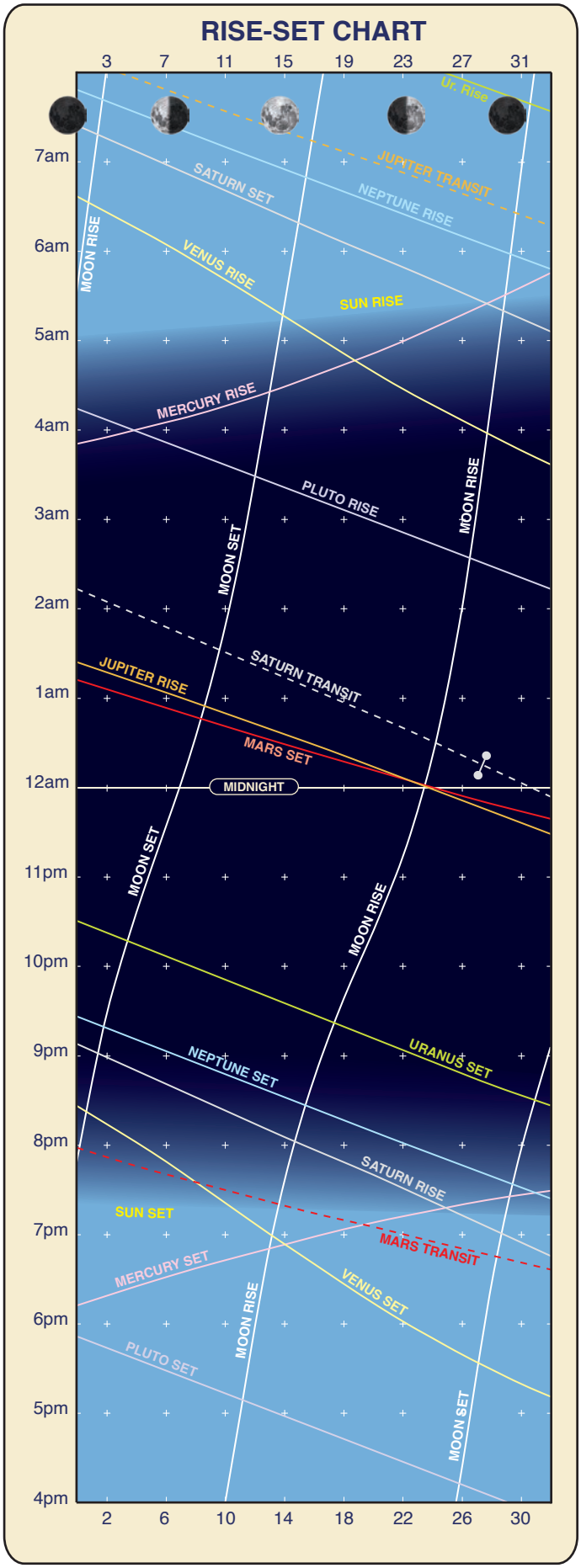
PLANET POSITIONS



This diagram illustrates the relative positions of the planets during the course of their orbits in 2006. The relationships between the major Solar System bodies are clearly shown. For example, this year's opposition of Saturn occurs late January when the Earth appears closest. A line extended from Earth, through and beyond Saturn, shows that the planet is located in Cancer. The diagram is drawn as viewed from below (south of) the Solar System. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the Sun and planet distances are not drawn to scale. The thirteen named constellations are those situated on the ecliptic.

JANUARY

RISE-SET CHART



HIGHLIGHTS

- Saturn at opposition.
- Saturn very close to open star cluster M44.
- Jupiter and the Moon are close.

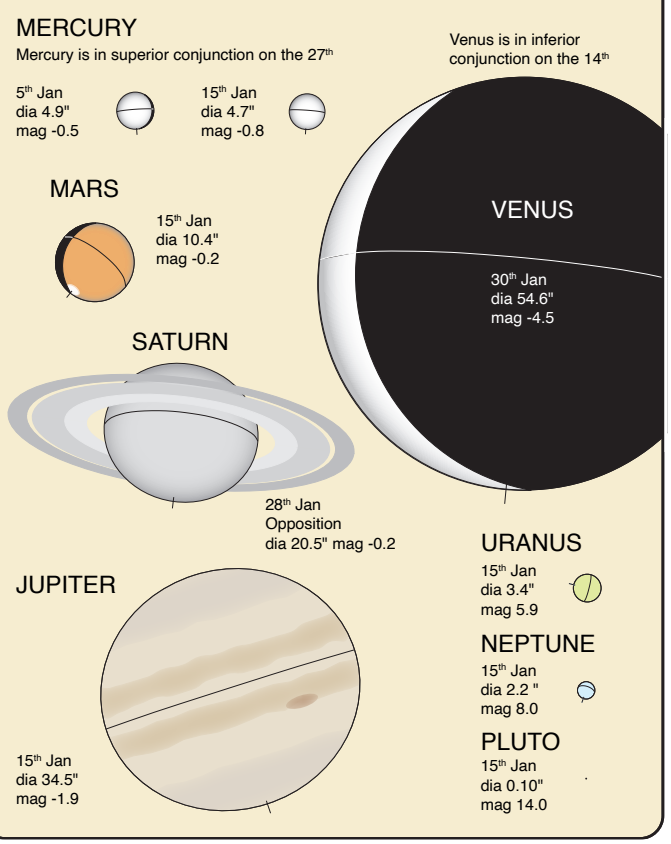
THE MOON

2nd	Moon at perigee (closest to Earth – 361,750 km distant, angular size 33.3').
7th	First Quarter.
14th	Full Moon.
18th	Moon at apogee (furthest from Earth – 405,885 km distant, angular size 29.7').
22nd	Occultation of Spica by the Moon. This occultation is not visible from Australia, however the Moon and Spica appear a few degrees apart in the early morning sky. This is the sixth in a series of nineteen occultations of Spica that began in September 2005, and will end in January 2007.
23rd	EST (22nd WST) Last Quarter.
25th	Occultation of Antares by the Moon, not visible from Australia. This is the fifteenth in a series of sixty-nine occultations of Antares that began in January 2005, and will end in February 2010.
30th	EST (29th WST) New Moon.
30th	Moon at perigee (closest to Earth – 357,778 km distant, angular size 33.6').

THE PLANETS

MERCURY is visible early in the month in the dawn sky in Sagittarius. The planet becomes increasing more difficult to view as it moves toward

APPEARANCE of the PLANETS



the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 27th. Thereafter Mercury moves east of the Sun to become an evening star during February. Much attention will be on this speedy little messenger in November when it transits the Sun's disc. This is the second of fourteen transits to occur this century; the last in May 2003 was visible from Australia. Let's pray for clear weather, as the following two are not visible from Australia (May 2016 and November 2019), and the next opportunity from our shores will be in twenty-six years time in 2032.

VENUS is in inferior conjunction on the 14th. Readers will recall the last inferior conjunction of Venus in June 2004 when the planet passed across the Sun's disc for the first time in 121 years, an event that will be repeated in June 2012. If you miss the 2012 transit, it is doubtful that you will be around for the next one in 2117.

Returning to January 2006, Venus spends the entire month in Sagittarius; firstly as the bright Evening Star in the first week of the month, and then as the Morning Star from mid-month until mid-September.

The **EARTH** is at perihelion (the closest point in its orbit around the Sun) on the 5th. The Earth/Sun distance is 0.983327 astronomical units, which is equivalent to 147,103,824 km. The average distance between the Sun and Earth is 149,597,870 km or 1 AU.

PROBING THE PLANETS UPDATE 2006

2005 Reviewed

The Moon After a long 13 month cruise the European probe SMART-1 finally entered lunar orbit in December 2004. The reason why it took so long was that its propulsion system used an economic, but slow, ion drive, which runs on the solar wind. SMART-1 went into a polar orbit and it is hoped it will settle the issue of whether or not the polar craters contain vast reservoirs of water locked up as subsurface ice.

Venus At the time of publication ESA were expecting to launch their Venus Express probe in October or November 2005, arriving at Venus 162 days later. The probe will study the Venusian atmosphere and clouds in unprecedented detail and accuracy.

Mars A highlight of 2005 was the continued operation of NASA's Spirit (MER-A) and Opportunity (MER-B) rovers. It was originally hoped these two identical robotic field geologists would operate for three months, which would have taken them to April 2004. However, they have well and truly exceeded expectations and, as of September 2005, are still roaming and gathering a wealth of scientific data.

The ESA's Mars Express probe successfully deployed its 20 metre MARSIS booms. This allows for radar sounding at night for water beneath the surface and will study the ionosphere by day.

Saturn On January 14, 2005, the Huygens probe entered the atmosphere of Titan and successfully parachuted to the surface. It returned to Earth a deluge of data during its two hour decent through the atmosphere and for a number of hours on the surface. It collected evidence of the presence of water, rocks (made of ice), methane rain, and took images of clouds, dry riverbeds and a coastline.

The Cassini spacecraft had a busy year in 2005 having eight encounters with Titan, two with Enceladus and one each with Hyperion, Dione and Rhea. Its discoveries included: Titan's Earth-like surface and organic atmosphere (with Huygens), the closest ever observations of the rings revealing moons, kinks and waves, Phoebe being a captured world from the outer Solar System, Saturn's dynamic atmosphere and a new radiation belt, and Iapetus' distinctive equatorial mountain range.

Comet The Deep Impact probe was launched in January 2005 and successfully delivered its 350 kg projectile to Comet Tempel 1, slamming into its nucleus on July 4. Despite hopes we would see a dramatic surge, only a slight increase was seen in the brightness of the nucleus, but even that was gone the next day. We just had to settle for the spectacular images from the flyby probe.

Minor Planet In September 2005, the Japanese probe Hayabusa reached the minor planet Itokawa. It will spend the next five months observing Itokawa, which will include landing, taking samples from the surface and returning them to Earth in 2007.

So What Will 2006 bring?

The Moon The SELenological and ENgineering Explorer (SELENE), Japan's first large lunar explorer, is now expected to be launched on January 1, 2006. The mission, which is the largest lunar project since the Apollo program, is keenly anticipated by many countries. The major objectives of the mission are to understand the Moon's origin and evolution, and to observe the Moon in various ways in order to utilize it in the future. The lunar missions that have been conducted so far have gathered a large amount of information on the Moon, but the mysteries of its origin and evolution have been left unsolved. SELENE will also have the ability to photograph the Apollo lunar landing sites but unfortunately this is unlikely to convince the lunar hoax people. You can already hear them screaming, "… they're faked as well!"

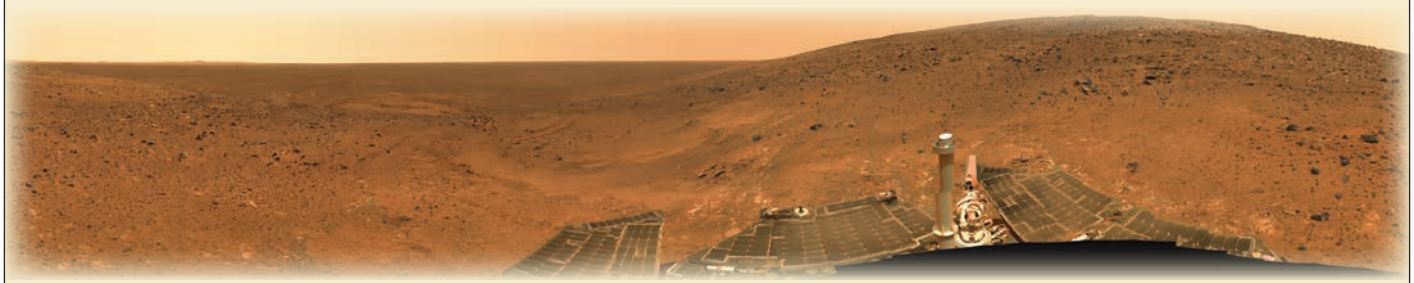
Mercury NASA's Messenger probe has been on route to Mercury since its launch in 2004. It will finally enter orbit in 2009, but it will first make one swing by of Earth, two flybys of Venus and one of Mercury. The brief return to Earth happened successfully on August 2 last year. On the 24th October this year we will see the first flyby of Venus, with the probe coming within 3,612km of the planet. Messenger stands for **ME**rcury **S**urface, **S**pace **EN**vironment, **GE**ochemistry and **R**anging mission.

Mars On August 12, 2005 the Mars Reconnaissance Orbiter (MRO) was successfully launched and will enter Mars' orbit in March 2006. It will image the entire surface at a high resolution; generate mineral composition maps and subsurface radar profiles. It will identify potential landing sites for two landers expected to be launched over the next five years. They are the Phoenix lander, scheduled to launch in 2007 which is expected to land in the polar region, and a large rover, Mars Science Laboratory, due to be sent on its way in 2009. MRO will also act as a communications relay station between the Earth and landers having a much more powerful transmitter than the current three orbiters — Global Surveyor, Mars Odyssey and Mars Express.

Saturn Cassini continues its 4-year mission exploring Saturn, its rings and suite of satellites. This includes an almost monthly encounter with Titan. Other moons being visited at least once during 2006 are: Helene, Rhea, Polydeuces, Telesto, Atlas, Methone, Calypso and Enceladus.

Pluto The New Horizons mission to Pluto and the Kuiper asteroid belt is due to launch in January 2006. After a one-year voyage to Jupiter, it will use a gravity-assisted flyby of this gas giant to arrive at Pluto in 2015.

Comet On January 2, 2004, the Stardust probe flew within 236 km of Comet Wild 2 and its 'aerogel' collected samples of the dust and gas from its coma. It will return this material to Earth on Jan 15, 2006. Let us hope it will have better success than the earlier Genesis probe that crashed into the Utah desert in September 2004 when its parachutes failed to deploy.



Mars rover Spirit's 'Independence' panorama, acquired July 6–13, 2005, from a position in the 'Columbia Hills' near the summit of 'Husband Hill' (the peak near the right side of this image) about 100 meters away from the rover and about 30 meters higher in elevation. Image credit: NASA/JPL/Cornell

MARS, in Aries all month, can be seen in the northwestern evening sky, setting around midnight by month end. Since its favourable opposition last November, the planet has been decreasing in magnitude and angular size, and this month sees Mars at its best for the year. On the 8th, the 9-day old Moon appears near the planet (see Sky View).

JUPITER rises shortly after midnight in Libra, where it remains until early December. During the month the planet remains close to the 3rd magnitude star Zuben El Genubi (Alpha Librae), the Southern Claw. On the 24th, the 23-day old Moon appears close to Jupiter (see Sky View).

SATURN is at opposition on the 28th, and the next month or so is the optimum period for observation of this planet at its brightest and largest. Observers will note a gradual closing up of the planet's rings over the course of the year (compare the Appearance of the Planets diagrams for January and December). This trend continues until the Earth passes through the ring plane in 2009, when they will appear edge-on. The planet can be seen in the northeastern sky in the early evening in Cancer, close to the open cluster M44 (also known as the Beehive or Praesepe). By month end Saturn will be located south of and very close to the outer members of this grand binocular cluster. On the evening of the 15th the 16-day old waning gibbous Moon is near the planet (see Sky View).

URANUS in Aquarius and **NEPTUNE** in Capricornus remain in their respective constellations during the year. Both planets are low in the western evening sky and will soon be in conjunction with the Sun, returning to the morning sky in March.

PLUTO returns to the morning sky after being in conjunction with the Sun last month. This distant member of the Solar System remains in Serpens Cauda, its home of the past few years, until mid-October when it moves into Ophiuchus and finally into Sagittarius in December. Pluto commences the year 0.5° southeast of 3.5 magnitude Xi (ξ) Serpentis. Retrograde motion will cause Pluto to make a return visit to this naked-eye star in July.

MINOR PLANETS. On the 5th 4 Vesta reaches opposition at magnitude 6.2 in Gemini. On the morning of the 23rd 3 Juno, before it sets, has a close encounter with 3.7 magnitude star Pi-5 (p^5) Orionis. The morning of the 29th is also interesting with 11th magnitude 6 Hebe rising while on the northwest edge of the Eagle Nebula. The first half of January sees 29 Amphitrite tour three globular clusters in Ophiuchus.

DIARY

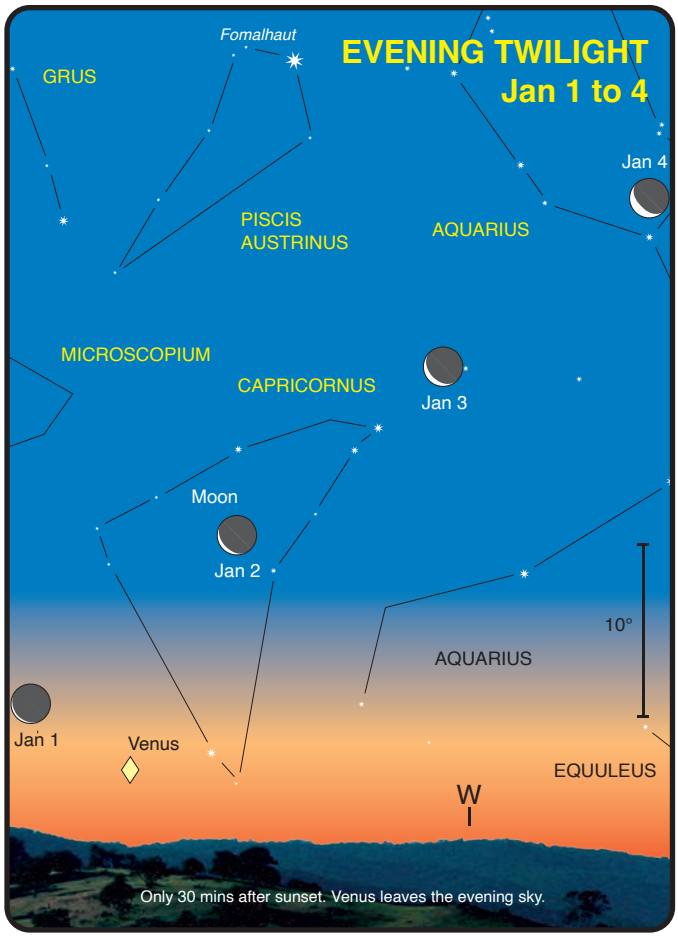
1st		Pluto 0.5°SE of star Xi Serpentis
1st		m.p. 20 Massalia 0.7°N of star Lambda Aquarii
1st	8pm	(6pm WST) Venus 7°N of Moon
2nd	9am	(7am WST) Moon at perigee
2nd		m.p. 29 Amphitrite 0.9°S of M19 (GC) in Ophiuchus
2nd	10pm	(8pm WST) Neptune 4°N of Moon
3rd		m.p. 10 Hygiea 0.3°N of NGC 6284 (GC) in Ophiuchus
4th	10am	(8am WST) Uranus 2°N of Moon
4th	8pm	(6pm WST) Neptune 0.05°NW of m.p. 18 Melpomene
5th	1am	(11pm WST, prev day) Earth at perihelion
5th		m.p. 25 Phocaea 0.8°N of star Eta Ophiuchi
6th	9am	(7am WST) m.p. 4 Vesta at opposition
6th		m.p. 29 Amphitrite 0.8°S of NGC 6293 (GC) in Ophiuchus
7th	4:56am	(2:56am WST) First Quarter
9th	6am	(4am WST) Mars 1.3°S of Moon
10th		Uranus 1.4°N of m.p. 44 Nysa
10th		m.p. 10 Hygiea 1.0°S of NGC 6325 (GC) in Ophiuchus
10th		m.p. 29 Amphitrite 0.5°N of NGC 6316 (GC) in Ophiuchus
10th		Mercury at aphelion
11th	3am	(1am WST) m.p. 15 Eunomia 0.2°W of NGC 6520 (OC) in Sagittarius
13th		m.p. 10 Hygiea 0.3°NE of star Theta Ophiuchi
14th	10am	(8am WST) Venus in inferior conjunction
14th	7:48pm	(5:48pm WST) Full Moon
15th		Jupiter 0.8°NE of star Alpha Librae
15th		m.p. 22 Kalliope 0.4°S of NGC 7723 (SG) in Aquarius
15th	11pm	(9pm WST) Saturn 4°S of Moon
17th	6am	(4am WST) m.p. 3 Juno stationary
17th		m.p. 22 Kalliope 0.8°SE of NGC 7727 (SG) in Aquarius
18th	5am	(3am WST) Moon at apogee
22nd	8am	(6am WST) Spica 0.6°S of Moon Occn.
22nd		m.p. 10 Hygiea 1.0°S of NGC 6401 (GC) in Ophiuchus
23rd	1am	(11pm WST, prev day) m.p. 3 Juno 0.05°SW of star Pi 5 Orionis
23rd	1:14am	(11:14pm WST, prev day) Last Quarter
24th	6am	(4am WST) Jupiter 5°N of Moon
24th		Venus at perihelion
24th		Comet C/2004 B1 (LINEAR) 0.1°E of NGC 6902 (SG) in Sagittarius
25th	10pm	(8pm WST) Antares 0.02°S of Moon Occn.
26th		m.p. 532 Herculina 0.7°N of star Zeta Ophiuchi
27th	8am	(6am WST) Mercury in superior conjunction
28th	9am	(7am WST) Saturn at opposition
28th	10am	(8am WST) Venus 12°N of Moon
29th	3am	(1am WST) m.p. 6 Hebe 0.1°NW of M16 (Eagle Neb.) in Serpens
29th		m.p. 6 Hebe 1.5°S of NGC 6604 (OC) in Serpens
30th	12:15am	(10:15pm WST, prev day) New Moon
30th		Uranus 1.0°N of m.p. 39 Laetitia
30th		m.p. 4 Vesta 0.8°SW of star Epsilon Geminorum
30th		Mercury at greatest latitude South
30th	6pm	(4pm WST) Moon at perigee
31st	10pm	(8pm WST) Uranus 1.7°N of Moon

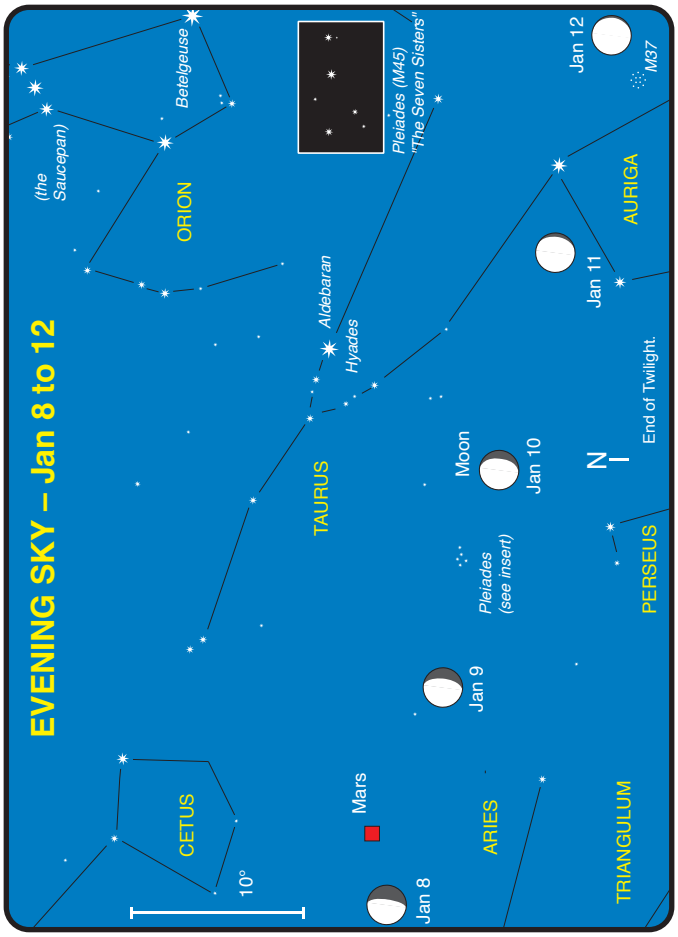
COMETS

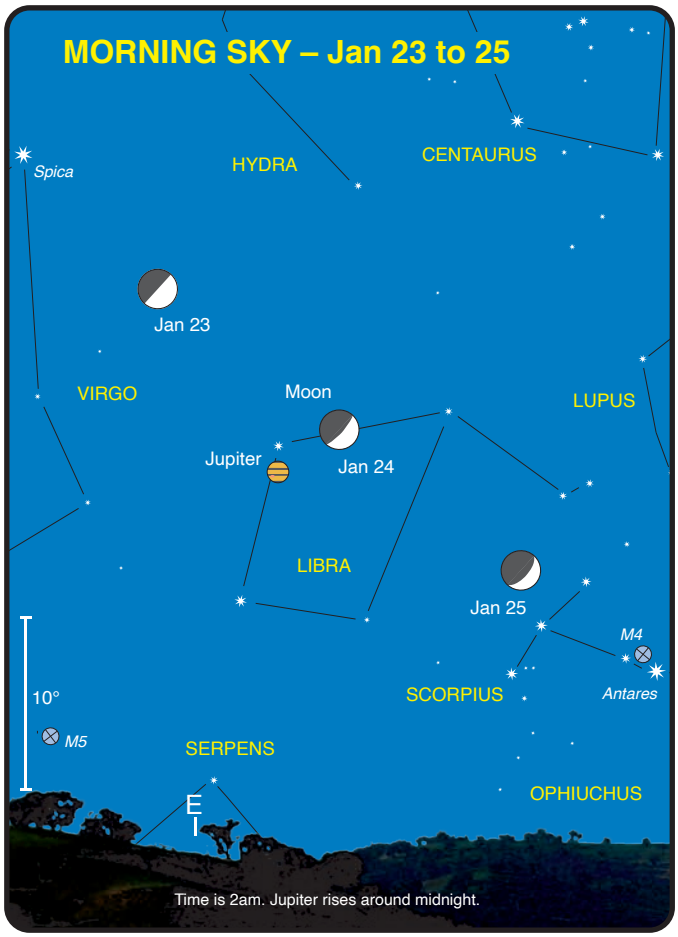
Comet C/2004 B1 (LINEAR) may be sighted at the beginning of January in Telescopium. Moving closer to the Sun, the 11th magnitude comet is setting in the evening and needs to be attempted as twilight ends.

METEOR SHOWERS

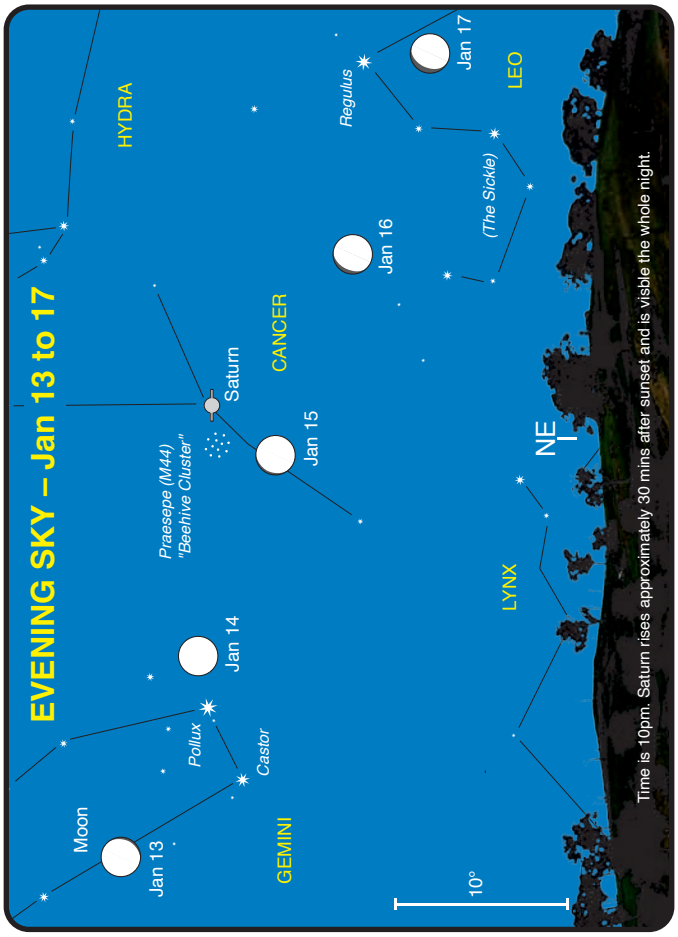
The **Quadrantids** are a strong and consistent northern shower. However, it is difficult for southern observers, with the radiant below the early morning northeastern horizon. If observing before dawn, the occasional long-pathed member may be glimpsed on the morning of the 4th. The Quadrantids are active from January 1–5, the zenith hourly rate is 120, but can vary from 40 to 200 per hour.

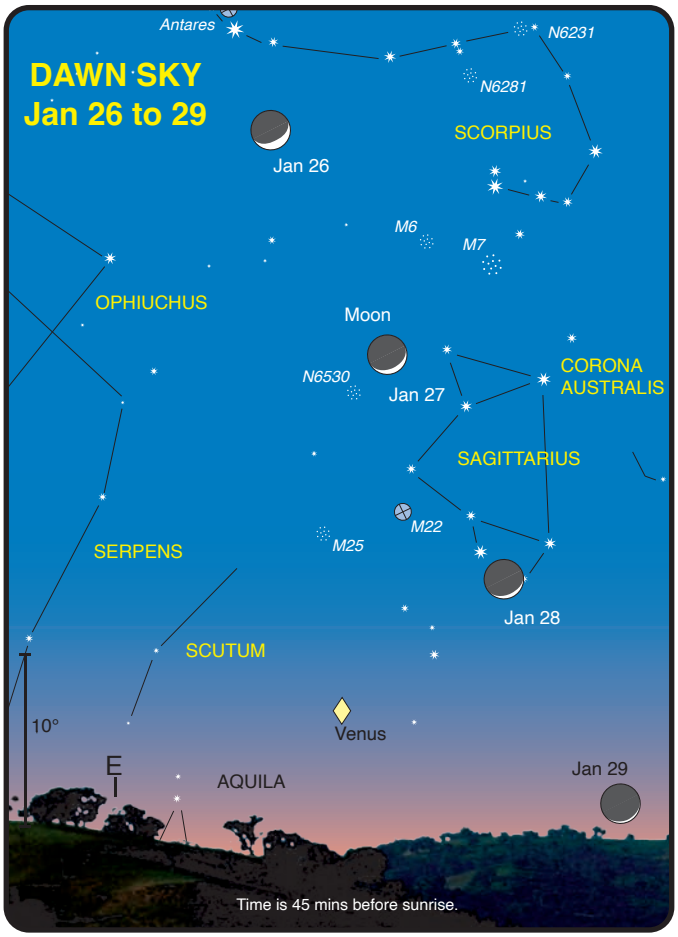






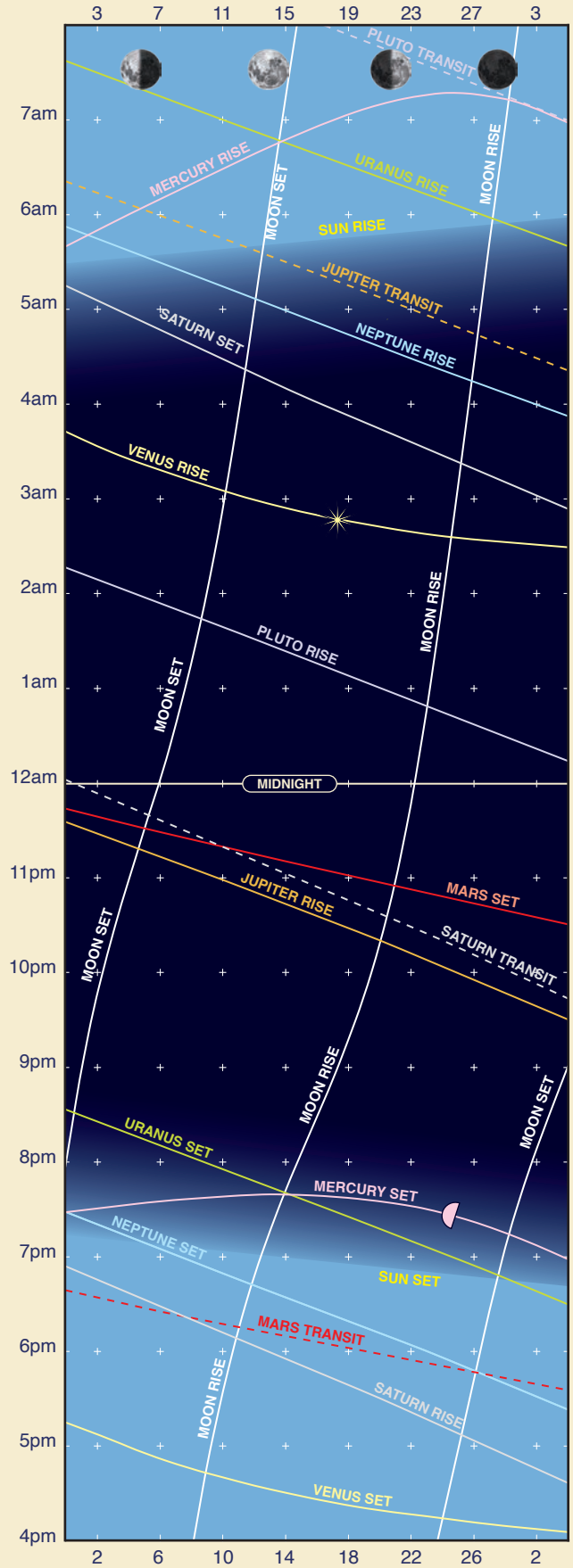
Approximate local standard time, for daylight saving add 1 hour.





FEBRUARY

RISE/SET CHART



HIGHLIGHTS

- Mercury returns to the evening sky.
- Venus at its brightest.
- Mars near the Pleiades star cluster.
- Saturn skims past the open star cluster M44.
- Occultation of Antares by the Moon (WA only).

THE MOON

5th First Quarter.

13th Full Moon.

14th Moon at apogee (furthest from Earth – 406,359 km distant, angular size 29.0').

18th Occultation of Spica by the Moon, not visible from Australia.

21st Last Quarter.

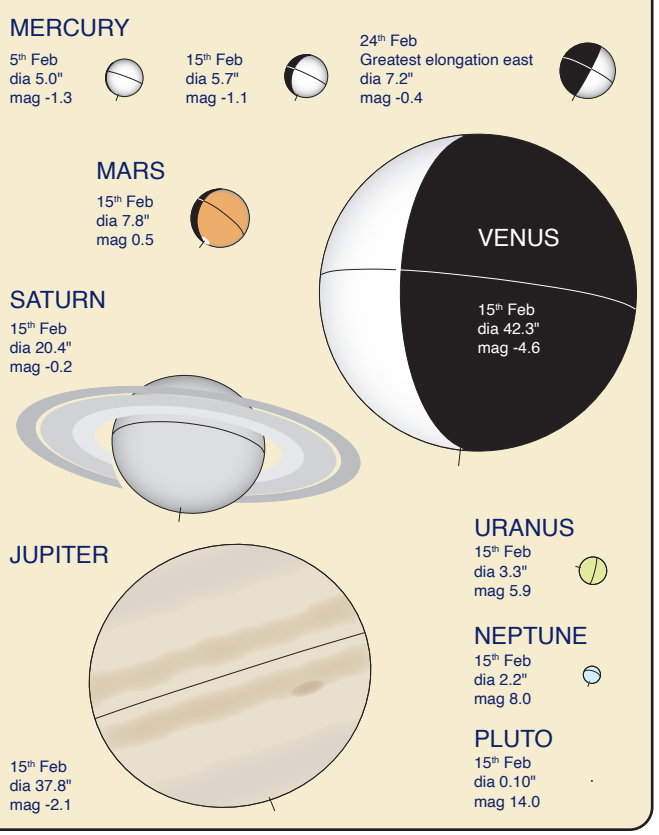
22nd Occultation of Antares by the Moon. This occultation is not really visible from the eastern or central states as it occurs either in the dawn or daytime skies. Observers from Western Australia fare better and will see the event from start to finish. For our Perth readers, Antares disappears behind the bright limb at 3:15am and reappears from the dark limb over an hour latter at 4:21am local time.

25th Occultation of minor planet Ceres by the Moon, not visible from Australia.

28th Moon at perigee (closest to Earth – 356,884 km distant, angular size 33.5').

28th New Moon.

APPEARANCE of the PLANETS



THE PLANETS

MERCURY returns to the evening sky this month. The planet's greatest elongation east of the Sun (18°) occurs on the 24th. This is not a particularly favourable elongation, with the planet in the western twilight sky setting shortly after the Sun. The best period for evening observation of this often difficult planet is during late September/ October. Just for interest, on the 14th, Mercury and Uranus are less than half a degree apart (an almost impossible observation as Uranus would not be visible in the twilight sky with the unaided eye).

VENUS, at magnitude -4.6, is at its brightest this month. The dazzling planet is visible high in the pre-dawn eastern sky in Sagittarius.

MARS can be seen in the northwestern evening sky, setting around 11pm. The Red Planet begins the month in Aries before crossing over into Taurus, where it will be seen close to the Pleiades star cluster around mid-month. The Pleiades cluster, commonly known as the Seven Sisters or by its Messier designation M45, is the most famous of all the open star clusters, and a magnificent binocular object.

JUPITER, in Libra, rises in the late evening eastern sky. On the 20th, the waxing gibbous Moon appears south of the planet (see Sky View).

SATURN, now past opposition, can be seen in the evening northeastern sky in Cancer. For the first two weeks of the month the ringed planet skims just above the open star cluster M44 (also known

NAKED EYE CHALLENGE

This year we would like to offer a slightly unusual suggestion for an observation. With a little practice, and good timing, you will not even require binoculars.

Observations of Callisto

The four Galilean moons of Jupiter are unique in the Solar System. They are the only satellites, except for our Moon, that could easily be visible to the naked-eye. Io is magnitude 5.1 with Europa, Ganymede and Callisto being 5.3, 4.6 and 5.7 respectively. Unfortunately, their proximity to the brilliance of Jupiter, typically around magnitude –2, makes observations with the unaided eye almost impossible, with the exception of Callisto. And that is only when it is at its maximum elongation. The table opposite shows these dates, which are graphically represented in Part II (see p. 114). At opposition, when the Earth is closest to Jupiter, Callisto can range as far as a little under 10 arc minutes from Jupiter. This distance is about equivalent to one third of the diameter of the Moon. Near conjunction, when Earth is on the opposite side of the Sun to Jupiter, this distance drops to about 6.7 arc minutes. So your best chance is around the time of opposition, which in 2006 is in early May.

The tools needed are quite simple.

1. Dark skies, away from cities, are needed. We are talking about a magnitude 5.7 object, which would be difficult to see from light polluted suburban skies. If you can see all the stars plotted on the All Sky Maps you have a chance. When planning an observing session, check the glare of the Moon doesn't interfere.
2. The critical part – a building, or even a carefully placed limb of a tree, to occult or block out the glare from Jupiter.

If you were looking towards the north, a western elongation would be on the left side of Jupiter so your occulting object should slowly be moved in front of Jupiter from the right to left. An eastern such event would be the opposite.

Considering how simple this experiment is it is interesting that after watching Jupiter for many centuries Mankind had to wait until Galileo used his telescope, in 1610, to discover Callisto!

Next Target – Vesta

Callisto is not the only minor body in the Solar System that can become visible to the unaided eye. The minor planet, 4 Vesta, can occasionally get brighter than 6th magnitude at opposition (around the time it is closest to the Earth). This is not the case for its return in 2006. These favourable apparitions occur about every 3 to 4 years. The last time this happened was in 2003 when it reached magnitude 5.9. The best return, earlier than this, was in 2000 when it achieved 5.4. Next year is another excellent opposition with Vesta again reaching 5.4. Magnitude 5.3 is about its maximum possible. You might ask why does the maximum brightness change from opposition to opposition? The reason is the same as why Mars can have brighter returns than others. It depends on where Vesta is in its orbit when the Earth makes its closest approach. The optimum time is when Vesta (like Mars) happens to be also making its closest approach to the Sun or its *perihelion*. This time of *perihelic opposition* is around the end of June for Vesta; it then drops off on either side. The 'naked-eye' period (brighter than 6th magnitude) is when opposition occurs in the period from April to August. For example the 2003 date was at the start of April at magnitude 5.9, just making it in. The 5.4 magnitude oppositions of 2000 and 2007 are in July and June respectively. We'll have more to say on this topic in Astronomy 2007.

Date (2006)	Distance (')	Direction from Jupiter
6 Jan	7.3	E
15 Jan	7.5	W
23 Jan	7.7	E
1 Feb	7.9	W
09 Feb	8.1	E
17 Feb	8.3	W
26 Feb	8.5	E
6 Mar	8.8	W
14 Mar	9.0	E
23 Mar	9.1	W
31 Mar	9.3	E
8 Apr	9.4	W
17 Apr	9.6	E
25 Apr	9.7	W
3 May	9.7	E
11 May	9.7	W
20 May	9.6	E
28 May	9.6	W
5 Jun	9.5	E
14 Jun	9.3	W
22 Jun	9.1	E
30 Jun	9.0	W
9 Jul	8.7	E
17 Jul	8.5	W
25 Jul	8.3	E
3 Aug	8.1	W
11 Aug	7.9	E
20 Aug	7.7	W
28 Aug	7.5	E

Callisto — Maximum Elongations for 2006 (within 4 months of opposition)

as the Beehive or Praesepe), being closest on the 6th. M44 has been known since antiquity, being visible to the unaided eye as a nebulous patch under dark skies. Galileo was the first to understand the true nature of Praesepe when he turned the newly invented telescope toward the object in 1610, revealing 36 stars. In all, several hundred stars are members of the cluster, which is over a degree across and is a good binocular or low power telescope object. On the 11th, the near Full Moon can be seen near Saturn (see Sky View).

URANUS is now very low in the western twilight sky as it moves towards conjunction early next month.

NEPTUNE is in conjunction with the Sun on the 6th, and moves into the morning sky mid-February. While not observable, it is of interest to note that during this conjunction the planet is occulted by the Sun's disk from our viewpoint. This is the seventh in a series of eight annual Neptunian conjunctions where an occultation occurs; the next series begins in the year 2080.

PLUTO rises around 1am in Serpens, remaining within 2° of the 3.5 magnitude star Xi Serpentis.

MINOR PLANETS at opposition this month include: 79 Eurynome on the 1st at magnitude 10.7 in Cancer, 324 Bamberga on the 6th at magnitude 10.8 in Cancer and 71 Niobe on the 18th at magnitude 10.5 in Sextans. A faint (11th magnitude) 10 Hygiea tours a number of deep sky objects in Sagittarius this month.

DIARY

1st		Saturn 0.9°S of Beehive Cluster M44 (OC) in Cancer
2nd		m.p. 25 Phocaea 0.3°S of NGC 6604 (OC) in Serpens
2nd		m.p. 25 Phocaea 1.2°S of Eagle Neb. (M16) in Serpens
3rd	5pm	(3pm WST) Venus stationary
4th		m.p. 25 Phocaea 0.3°S of NGC 6625 (OC) in Scutum
5th	3am	(1am WST) m.p. 15 Eunomia 0.1°W of star Phi Sagittarii
5th		m.p. 10 Hygiea 0.5°S of Lagoon Neb. (M8) in Sagittarius
5th		m.p. 29 Amphitrite 0.4°S of NGC 6520 (OC) in Sagittarius
5th	4:29pm	(2:29pm WST) First Quarter
6th	8am	(6am WST) Mars 2°S of Moon
6th		m.p. 25 Phocaea 0.3°E of NGC 6631 (OC) in Scutum
6th	4pm	(2pm WST) Neptune in conjunction with Sun
7th		m.p. 10 Hygiea 0.2°NW of NGC 6544 (GC) in Sagittarius
8th		Comet 29P/Schwassmann-Wachmann 1 0.7°N of star Beta Arietis
10th		m.p. 15 Eunomia 0.4°S of star Sigma Sagittarii
12th	1am	(11pm WST, prev day) Saturn 4°S of Moon
13th	2:44pm	(12:44pm WST) Full Moon
14th	11am	(9am WST) Moon at apogee
15th	2am	(Midnight WST, prev day) Mercury 0.03°N of Uranus
15th		Venus at greatest latitude North
15th	pm	m.p. 9 Metis 0.9°NE of NGC 3628 (SG) in Leo
16th		Mars 2.6°S of The Pleiades (M45) in Taurus
18th	6am	(4am WST) Venus greatest illuminated extent
18th		m.p. 10 Hygiea 0.2°NE of M28 (GC) in Sagittarius
18th		Mercury at ascending node
18th	3pm	(1pm WST) Spica 0.4°S of Moon Occn.
20th		m.p. 10 Hygiea 0.8°N of star Lambda Sagittarii
20th	6pm	(4pm WST) Jupiter 5°N of Moon
21st	5:17pm	(3:17pm WST) Last Quarter
22nd	7am	(5am WST) Antares 0.2°N of Moon Occn.
22nd		m.p. 10 Hygiea 0.9°N of NGC 6638 (GC) in Sagittarius
22nd		m.p. 68 Leto 0.1°S of NGC 6907 (SG) in Capricornus
22nd		Mercury at perihelion
23rd	6pm	(4pm WST) m.p. 4 Vesta stationary
23rd	pm	m.p. 9 Metis 0.5°NE of NGC 3596 (SG) in Leo
24th	3pm	(1pm WST) Mercury greatest elongation East (18°)
25th	7am	(5am WST) Venus 10°N of Moon
25th		m.p. 10 Hygiea 0.6°S of M22 (GC) in Sagittarius
25th	8pm	(6pm WST) m.p. 1 Ceres 0.8°N of Moon Occn.
25th	11pm	(9pm WST) m.p. 9 Metis 0.05°S of star Theta Leonis
26th	11pm	(9pm WST) Neptune 4°N of Moon
28th	6am	(4am WST) Moon at perigee
28th	10:31am	(8:31am WST) New Moon

COMETS

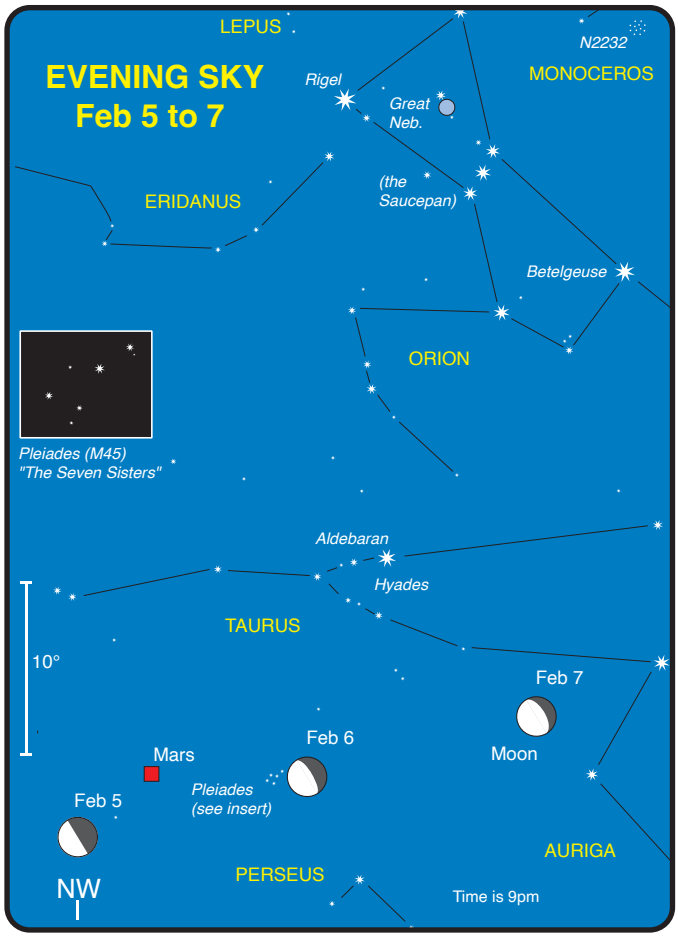
Comet C/2004 B1 (LINEAR) should become visible in the morning sky towards the end of February. It reaches perihelion at 1.6 AU, and the 10th magnitude comet will be moving north along the Microscopium-Sagittarius border.

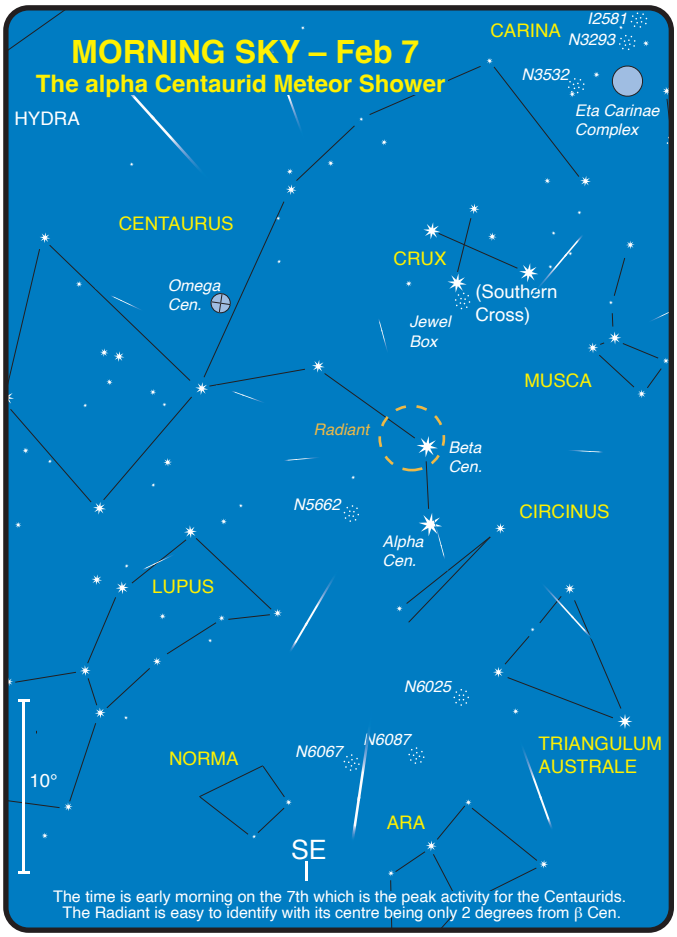
Comet 73P/Schwassmann-Wachmann 3-C (see page 130 for the background on this comet) may brighten from 13th to 11th magnitude this month. Visible in the morning sky (rising late in the evening), the comet moves northeast through Virgo and Bootes. It will be important to see how bright it is at this early stage as it heads towards a very close approach to Earth, and predicted naked-eye brightness, in May.

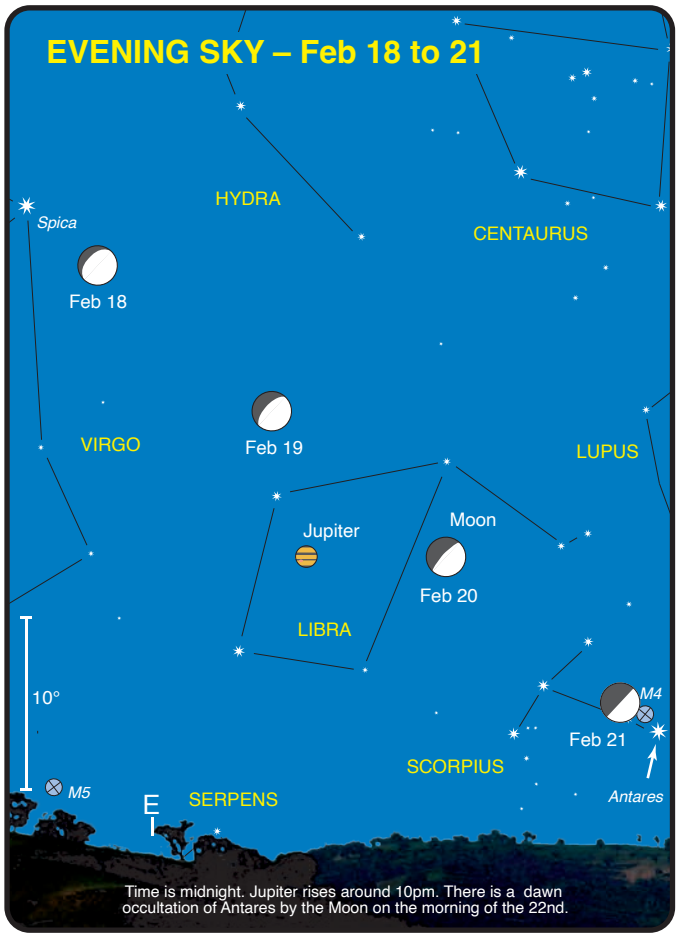
METEOR SHOWERS

The **alpha-Centaurids** are active from 28th January through to 21st February, with maximum on the 7th (see Sky View). Their zenith hourly rate is unpredictable, around 5 to 10 per hour at best, but high rates sometimes occur every 4 to 6 years. Most recently, in 1974 and 1980 the rate was 20 to 30 per hour. This increase is always temporary, lasting no more than 2–3 hours. The shower is noted for its brightly coloured fireballs that frequently reach negative magnitudes (up to –3 or more). They are predominantly yellow or blue, but their range can cover the entire spectrum. The Alpha Centaurids are also well known for their long lasting trains (about 25 to 30 percent of the meteors) that may last from a few seconds to several minutes. The First Quarter Moon spoils the first half of the night, however the morning sky will be free of any interference.

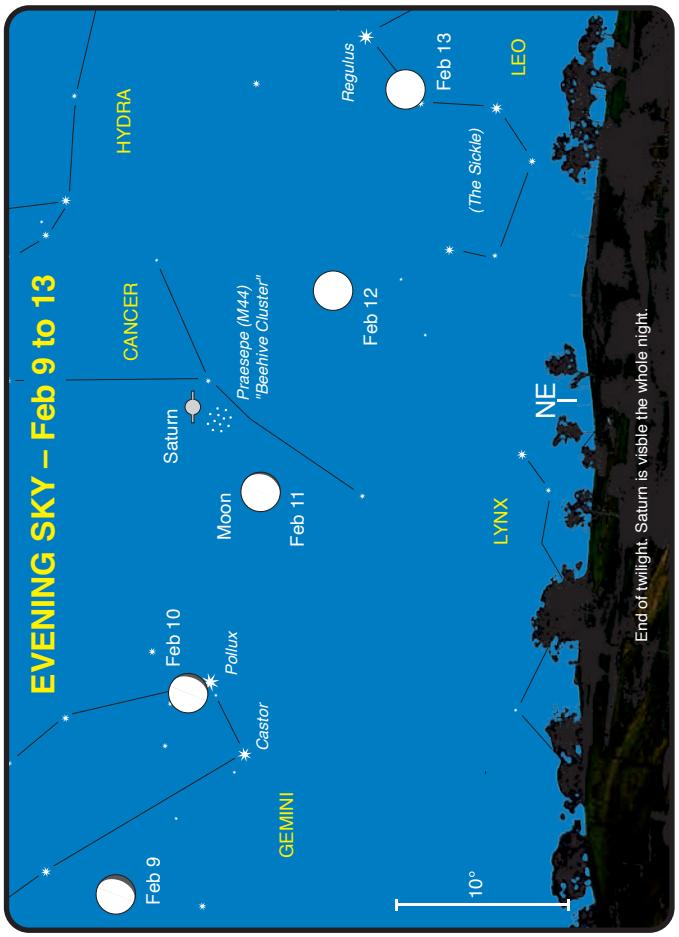
The **delta-Leonids** are not well placed for southern observers, but with the radiant near the 'sickle' or 'head' of Leo, it will be above the northern horizon for a few hours late evening and early morning. With predominately faint meteors this shower is considered a minor one, active from 15th February to 10th March, with maximum on the 24th; a low zenith hourly rate of around 2 can be expected.

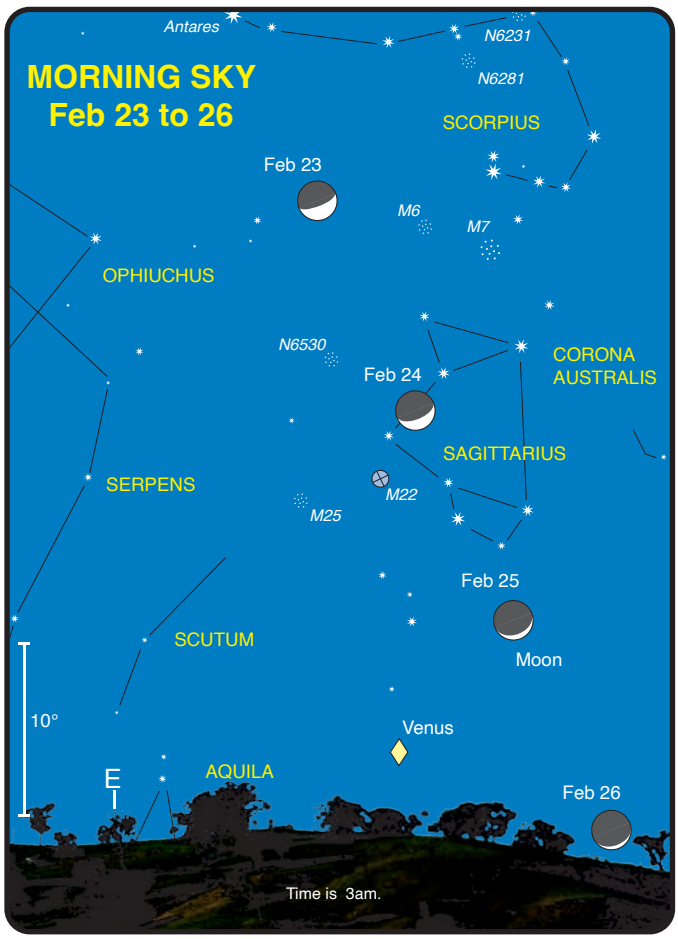






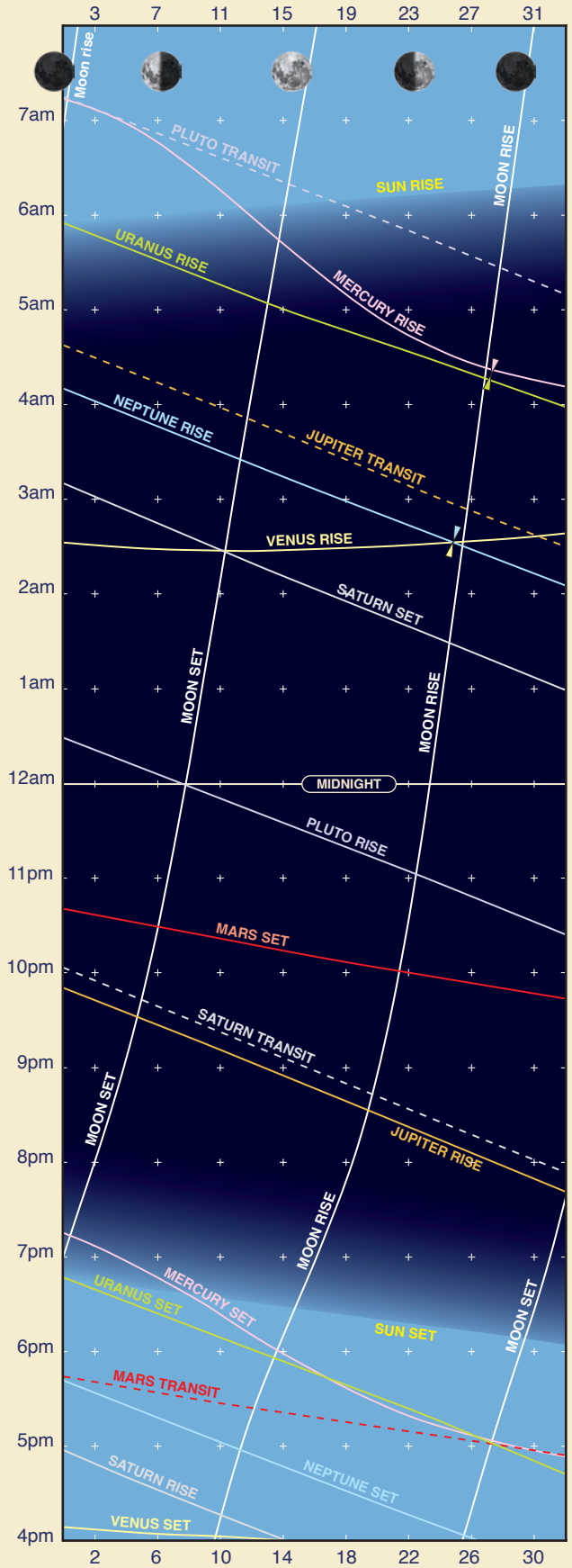
Approximate local standard time, for daylight saving add 1 hour.





MARCH

RISE/SET CHART



Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Spica and Moon very close on rising.
- Mercury at best in morning sky this year.
- Mercury, Moon and Uranus close.
- Venus and Neptune close.
- Minor Planet 40 Harmonia visits M65 and M66.

THE MOON

7th First Quarter.

13th Moon at apogee (furthest from Earth – 406,278 km distant, angular size 29.0').

15th Full Moon. Penumbral eclipse visible in its entirety from Africa and Europe. Technically the Moon makes contact with the Earth's penumbral shadow over the western portion of Australia, but due to the faintness of this type of eclipse it will not be visible in the dawn sky.

17th Occultation of Spica by the Moon, not visible from Australia. However, the 1st magnitude star appears just above the waxing gibbous Moon as it rises in the early evening sky.

21st Occultation of Antares by the Moon, not visible from Australia.

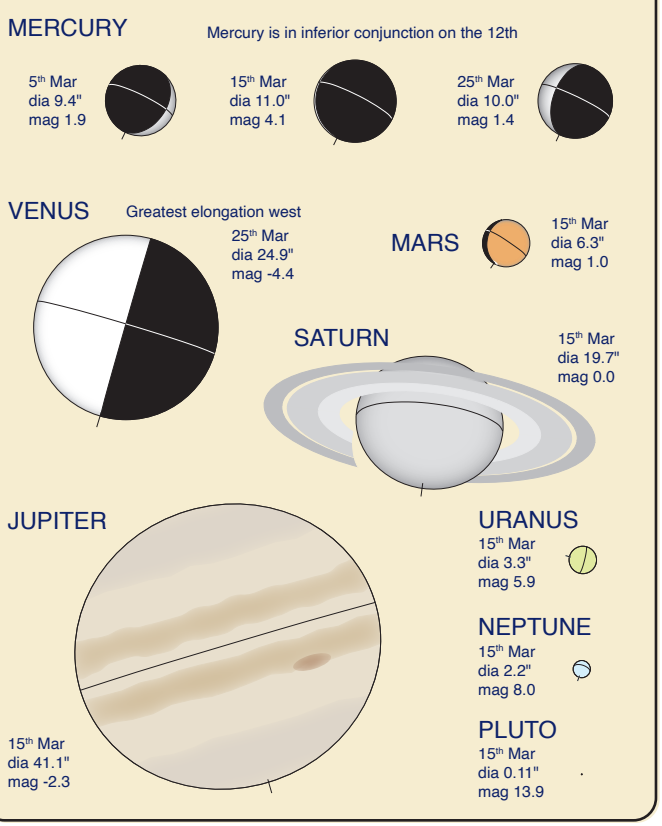
23rd Last Quarter.

25th Occultation of minor planet Ceres by the Moon, not visible from Australia.

28th Moon at perigee (closest to Earth – 359,168 km distant, angular size 33.3').

29th New Moon. Total solar eclipse visible over parts of Africa and Europe.

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is in inferior conjunction (between Earth and Sun) on the 12th, and then moves west of the Sun into the morning sky. The period from late March through to the end of April marks the best time to observe this sometimes elusive planet in the morning sky this year. For most of this time Mercury rises two hours ahead of the Sun providing ample opportunity for observation. On the 28th, the slender lunar crescent (just four percent illuminated) appears below and south of the planet (see Sky View). On the same morning Mercury and Uranus are just 1.5° apart, with Uranus above Mercury and a little to the south. Low power binoculars (7 X 50 for example) should provide a pleasing view and even pick up Uranus from suburban skies.

From Earth we will enjoy a transit of Mercury across the face of the Sun in November this year, however any Jovians who may be looking sunward on the 26th of this month will also have the opportunity to see a similar transit.

VENUS rises around 2:30am and spends the first week of the month in Sagittarius, then moves into Capricornus for the next fortnight, into Aquarius for a short visit, then back to Capricornus at month end. Like Mercury, Venus also has a close approach to one of the more distant planets, Neptune; on the 26th and 27th the pair will be 2° apart. Venus is at its greatest elongation west of the Sun (47°) on the 25th, and from now it will gradually move toward the Sun and superior conjunction in late October.

CONSTELLATIONS IN 3D

When looking at the night sky there is something missing — we only see a flat universe. When looking at a bright star we don't know if that star happens to be so brilliant because it is intrinsically brighter than the others or that it happens to be closer. Unfortunately, because of the sheer distances involved we can't see how far away the stars are.

With our 'two eyed' (overlapping vision) view of the world, we see two slightly different perspectives of nearby objects, one from each eye. This is the basis of stereovision or 3D. The diagrams here represent some well known star patterns which, when looked at the right way, can give a pseudo 3D view showing the stars placed at their varying distances. Some stars (well… dots) appear to float above the page and some below. We say pseudo, for to see this in the night sky would require your eyes to be a number of light years (ly) apart!

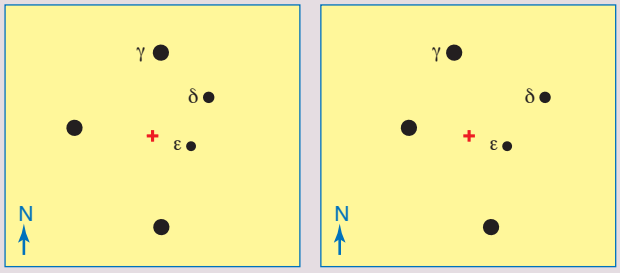
Seeing 3D

Seeing pairs of specially designed diagrams or photos as a 3D image is referred to as stereopsis. It is common to use stereo viewers, but with a little practice the effect can be seen with no aid at all. Once the method 'clicks in' you'll soon be able to repeat it easily. If you hold a finger, say 20cm from your face, while looking in the distance, and merge the two 'fingers' into one focused image — then you have all the skills needed for this technique. If you need glasses, even if only for reading, wear them and try this in a well lit location. Relax your eyes and focus on some distant object, even if only on the other side of the room. Slide the book in front of your eyes, closer than your normal reading distance. Each pair may now show four boxes, two for each eye. The trick is to merge the centre two images, which are likely already overlapped to some degree. Do this by starting to focus your eyes on the page but stop when the inner boxes, and their red crosses in the middle, are aligned precisely (on top of each other). Ensure the book is level and flat. Moving the book away towards your normal reading distance may help with the final focus. Sometimes the stereo effect can look mirrored with the furthest stars now looking the closest. If this happens, relax your eyes and start again. The following website may also help.

http://www.vision3d.com/stereo.html

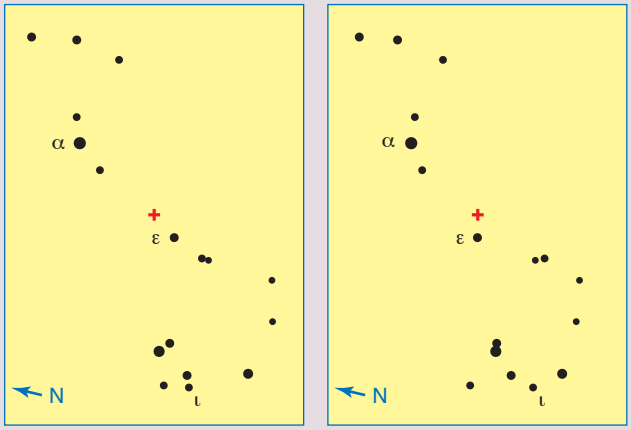
NB. The scale of each of the diagrams is different, having to cope with the different sizes of the constellations and distance ranges. The star distances have been taken from the Tycho and Hipparcos catalogues.

The Southern Cross (Crux)



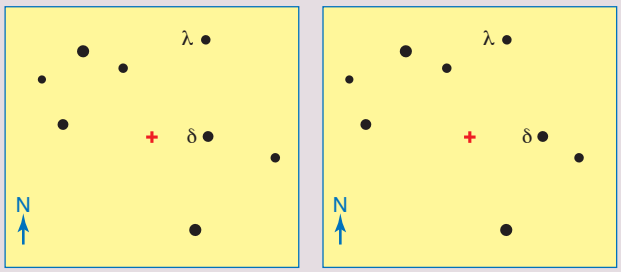
Crux. The red cross and the surrounding rectangle are at a distance of 226 ly (think of this as the plane of the paper). The main stars of Crux vary in distance from 87 ly for gamma (γ) out to 362 ly for delta (δ). Gamma really stands out compared to its more distant companions. It needs to be this close to appear this bright in the sky for it is an intrinsically faint (M class) orange star. If your stereovision is working well you should see one star closer than 226 ly which is γ, one about the same distance, epsilon (ε) (sitting in the plane of the paper) and the remaining three beyond.

The Body of Scorpius



Scorpius. The 'paper' is at a distance of 446 ly. These main stars, that form the distinctive body of the scorpion, range in distance from 65 ly epsilon (ε) out to iota (ι^1) Scorpii which is 1800 ly away. To minimise eyestrain this star is plotted only about half its true distance. Antares (α) is 600 ly away. With stereovision you should see seven stars closer than 446 ly (above the paper), one or two about the same distance and the remaining beyond.

The Teapot of Sagittarius



Sagittarius. The 'paper' is at a distance of 190 ly. The stars range in distance from Lambda (λ) at 77 ly out to Delta (δ), 305 ly. With stereovision you should see five stars closer than 190 ly and the remaining beyond.

The **EARTH** is at its autumnal equinox on the 21st. The Sun rises and sets due east and west and day and night are equal.

MARS is in the northwestern evening sky in Taurus, setting around 10pm. The Martian globe has now shrunk to around six arc seconds in diameter since opposition last November, and telescopic observation will reveal very little detail. On the 6th, the Red Planet and the First Quarter Moon appear close (see Sky View).

JUPITER, in Libra, rises in the mid-evening eastern sky. On the 19th, the 19-day old waning Moon appears a few degrees south of the planet (see Sky View). Jupiter begins retrograde motion early in the month, and the path of the planet will appear to move from east to west. This reversal of direction occurs for the outer planets around opposition, and for Jupiter it will continue until early July (see Retrograde Motion on page 80). On the 2nd, the 5th magnitude star Nu Librae is only 3 arc minutes south of Jupiter, making a nice binocular 'double star'.

SATURN, in Cancer, transits the meridian around 9pm. Now past opposition, the planet is still well placed for early evening observation.

URANUS returns to the morning sky in the second half of March. On the 28th, this outer world is in close proximity to Mercury and the Moon (see Mercury).

DIARY

1st	Noon	(10am WST) Mercury 4°N of Moon
1st	9pm	(7pm WST) Uranus in conjunction with Sun
2nd		Jupiter 0.05°N of star Nu Librae
2nd	5pm	(3pm WST) Mercury stationary
5th	10am	(8am WST) Jupiter stationary
5th		m.p. 1 Ceres 1.1°N of NGC 6907 (SG) in Capricornus
5th		Mercury at greatest latitude North
6th	5pm	(3pm WST) Mars 3°S of Moon
7th	6:16am	(4:16am WST) First Quarter
10th		m.p. 3 Juno 0.6°NW of star Lambda Orionis
11th	4am	(2am WST) Saturn 4°S of Moon
11th	10am	(8am WST) Mars 7°N of Aldebaran
12th	1pm	(11am WST) Mercury in inferior conjunction
13th	Noon	(10am WST) Moon at apogee
15th	9:35am	(7:35am WST) Full Moon; Penumbral Eclipse
15th		Comet C/2004 B1 (LINEAR) 0.5°N of m.p. 349 Dembowska
17th		m.p. 29 Amphitrite 0.7°S of star Tau Sagittarii
17th	9pm	(7pm WST) Spica 0.3°S of Moon; Occn.
18th	pm	m.p. 40 Harmonia 1.0°SW of M66 (SG) in Leo
18th	pm	m.p. 40 Harmonia 0.9°S of M65 (SG) in Leo
19th	Midnight	(10pm WST) Jupiter 5°N of Moon
20th		m.p. 6 Hebe 1.4°S of NGC 6814 (SG) in Aquila
21st	4am	(2am WST) Equinox
21st		m.p. 704 Interamnia 0.4°SE of M72 (GC) in Aquarius
21st	1pm	(11am WST) Antares 0.3°N of Moon Occn.
22nd		Mars 0.7°N of NGC 1746 (OC) in Taurus
22nd		m.p. 4 Vesta 0.7°N of star Epsilon Geminorum
22nd	pm	m.p. 40 Harmonia 0.3°SW of NGC 3593 (SG) in Leo
23rd	5:11am	(3:11am WST) Last Quarter
24th		m.p. 704 Interamnia 0.3°N of M73 (OC) in Aquarius
24th	10pm	(8pm WST) Mercury stationary
24th	pm	Comet 73P/Schwassmann-Wachmann 3-B 1.0°SE of star Arcturus
25th	5pm	(3pm WST) Venus greatest elongation West (47°)
25th	10pm	(8pm WST) m.p. 1 Ceres 0.8°S of Moon Occn.
26th	9am	(7am WST) Venus 6°N of Moon
26th	11am	(9am WST) Neptune 4°N of Moon
26th	Noon	(10am WST) Transit of Mercury across the Sun as seen from Jupiter
26th	pm	Comet 71P/Clark 0.3°NE of NGC 6342 (GC) in Ophiuchus
27th	7am	(5am WST) Venus 1.9°N of Neptune
28th	1am	(11pm WST, prev day) Uranus 1.4°N of Moon Occn.
28th	3am	(1am WST) Mercury 2°N of Moon
28th		Mercury at descending node
28th	5pm	(3pm WST) Moon at perigee
29th		m.p. 15 Eunomia 1.1°S of M75 (GC) in Sagittarius
29th		m.p. 704 Interamnia 0.3°SE of Saturn Neb. (PN) in Aquarius
29th	8:15pm	(6:15pm WST) New Moon; Eclipse
30th	1am	(11pm WST, prev day) Pluto stationary

NEPTUNE, in Capricornus, is located in the eastern morning sky, rising around 3am mid-month. On the 26th and 27th Neptune and Venus are close (see Venus). It is interesting to note that both inner planets are in close proximity to two of the outermost planets in the same region of sky and at the same time.

PLUTO rises around midnight in Serpens. This distant planet begins retrograde motion at month end, and remains so until early September.

MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Leo. They are: 9 Metis on the 2nd at magnitude 9.1, 40 Harmonia on the 8th at magnitude 9.9 and 32 Pomona on the 14th at magnitude 10.5. Others at opposition include 12 Victoria on the 14th at magnitude 10.7 in Crater and 64 Angelina on the 26th at magnitude 10.6 in Virgo. 40 Harmonia, just past opposition, visits M65 and M66 on the 18th.

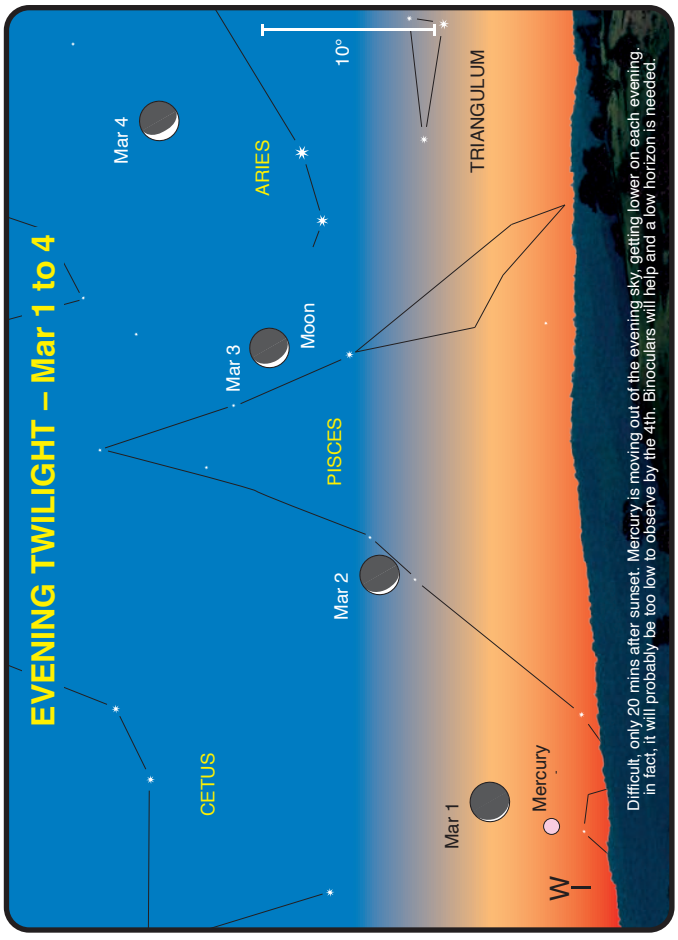
COMETS

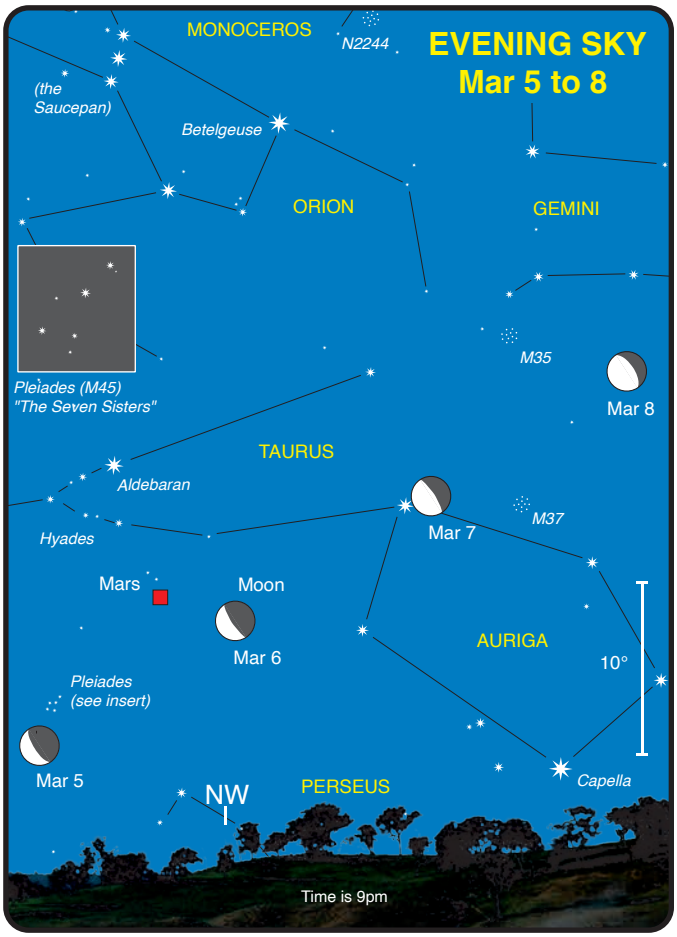
Comet C/2004 B1 (LINEAR) is a morning object, best observed before the beginning of dawn. The 10th magnitude comet will be found moving northward through Microscopium and Capricornus.

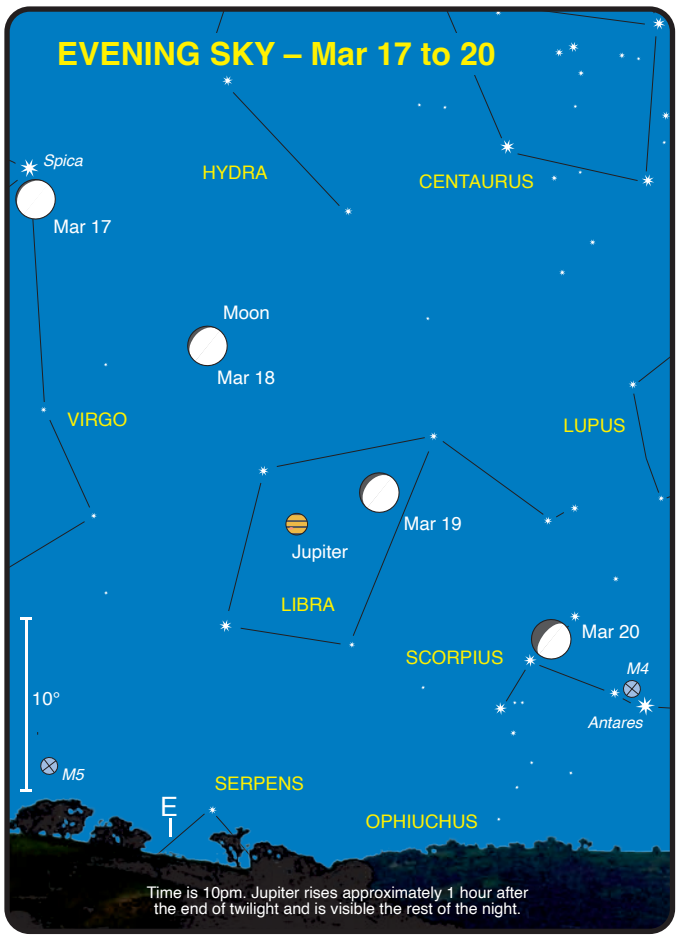
Comet 71P/Clark may brighten to 13th magnitude by the end of March. Observable in the morning sky, the comet is moving southeast through Ophiuchus. In late March, the comet is within two degrees of the globular cluster M9.

Comet 73P/Schwassmann-Wachmann 3-B (see page 130 for the background on this comet) could brighten to 12th magnitude by month's end. The comet is moving northeast through Bootes, and remains within 2 degrees northwest of the brighter fragment C (see below). On the 24th it will be 1° southeast of Arcturus.

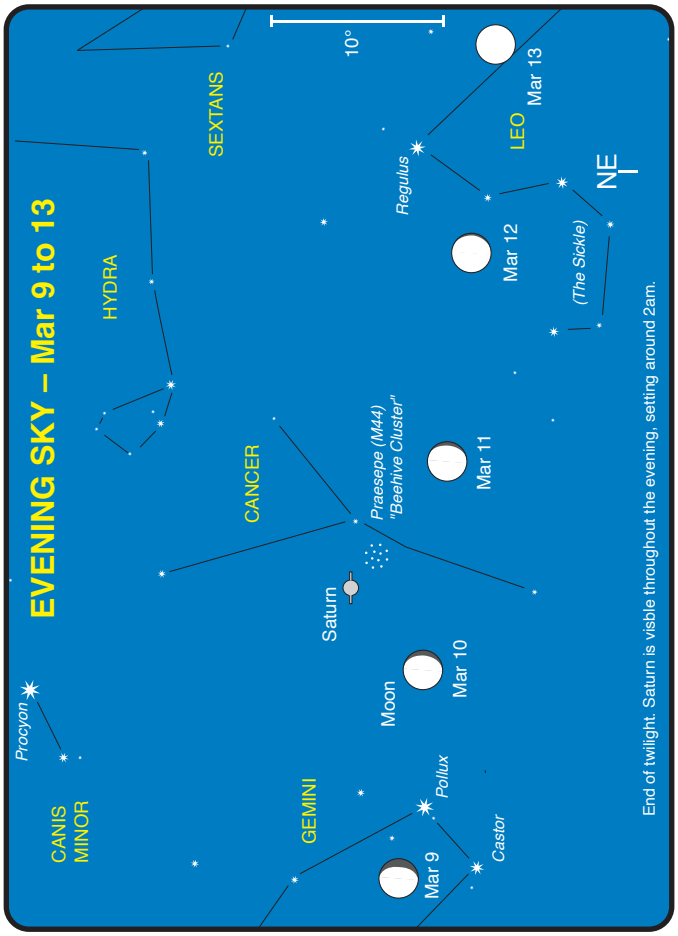
Comet 73P/Schwassmann-Wachmann 3-C begins the month perhaps at 11th magnitude in Bootes in the morning sky. It moves northeast through Bootes as March progresses, and in late March, when it might be 9th magnitude, it will be in the same binocular field as Arcturus (Alpha Bootis), see finder chart on page 39. Rising mid-evening, but best observed after midnight, the comet could be 8th magnitude by month end.

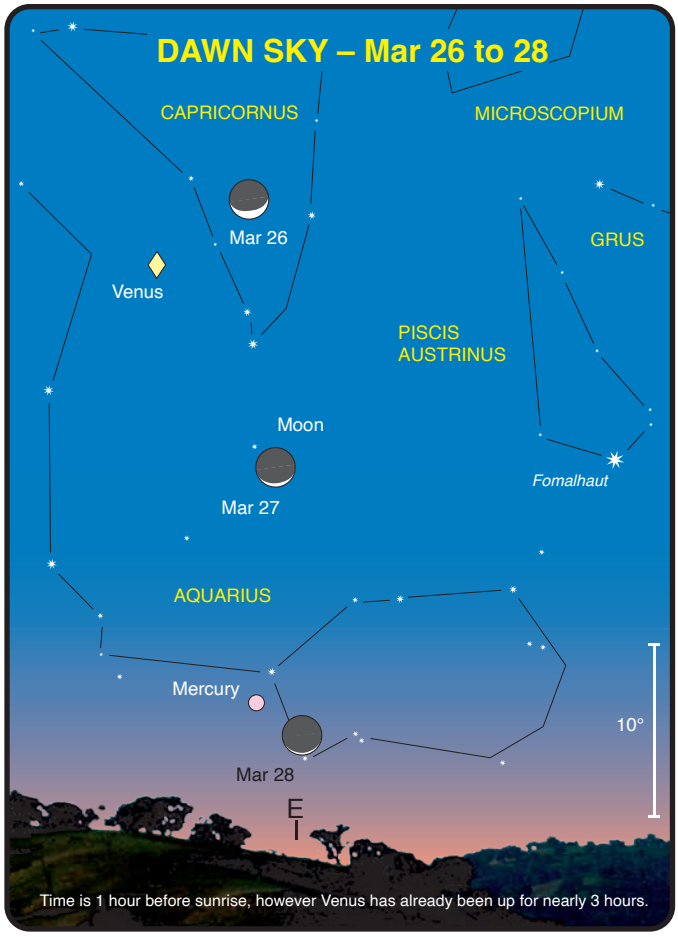






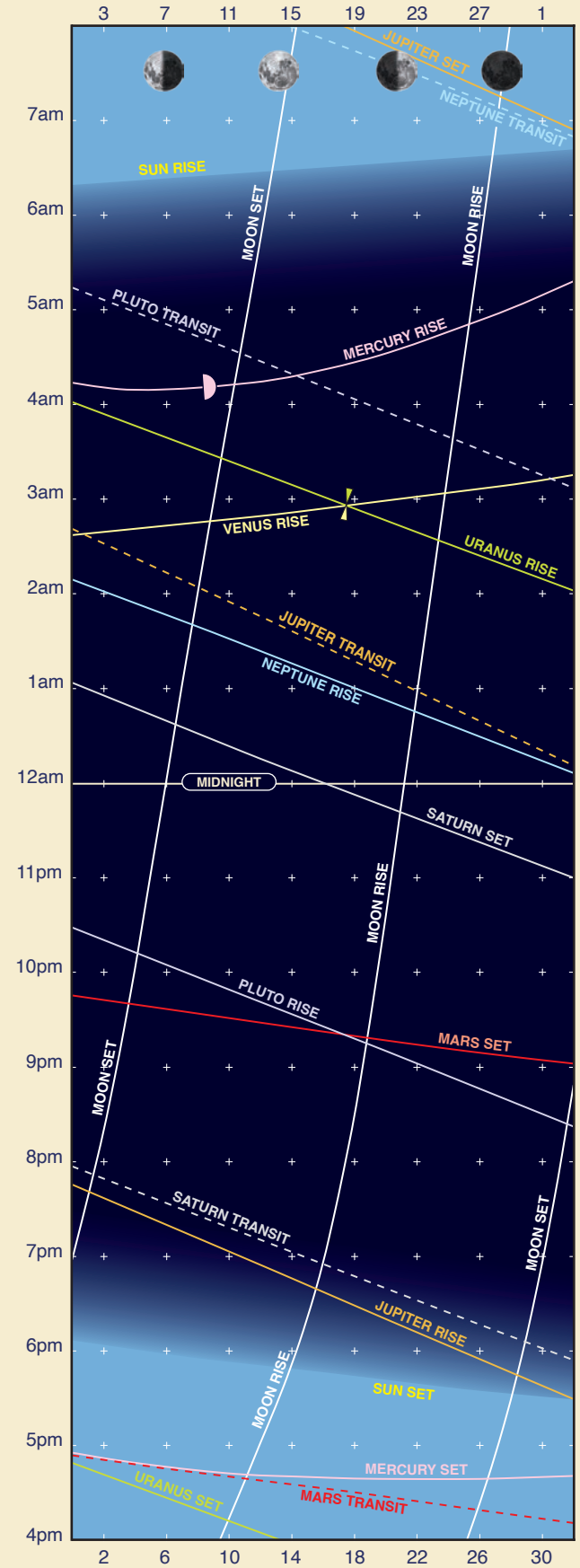
Approximate local standard time, for daylight saving add 1 hour.





APRIL

RISE/SET CHART



HIGHLIGHTS

- Best period for morning observation of Mercury.
- Spica close to the Moon (occultation from northern regions of Australia).
- Venus and Uranus very close.
- The pi-Puppids meteor shower.
- Comet 73P/Schwassmann-Wachmann 3, fragment C may be a naked-eye object by month end.

THE MOON

5th First Quarter.

9th Moon at apogee (furthest from Earth – 405,551 km distant, angular size 29.7').

14th Full Moon.

14th Occultation of Spica by the Moon, visible only from northern parts of Australia. From Darwin, Spica disappears behind the lunar limb at 3:27am and reappears at 4:47am. From all other capital cities Spica and the Moon appear very close in the morning hours.

17th Occultation of Antares by the Moon, not visible from Australia. Antares can be seen just a few degrees above the Moon on rising (see Sky View).

21st Last Quarter.

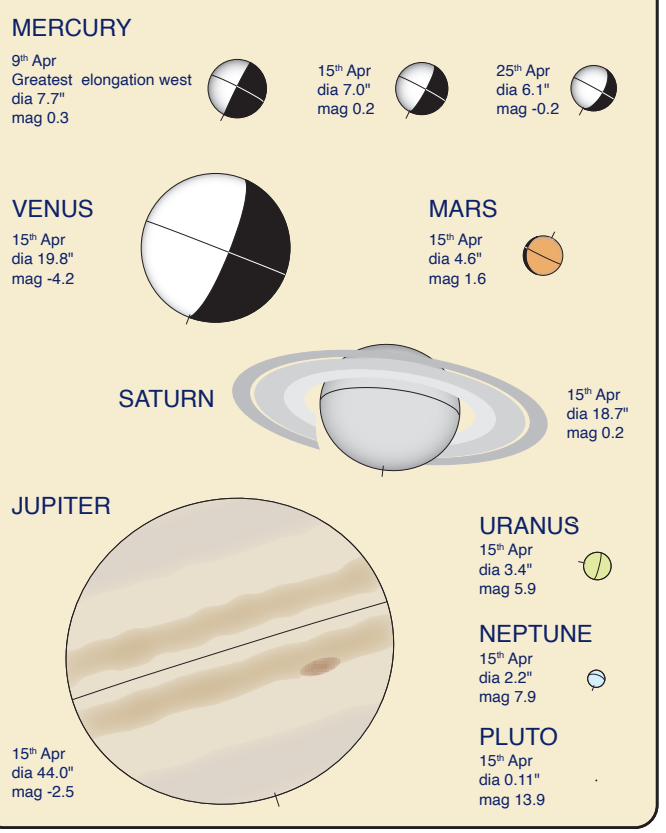
24th Occultation of Uranus by the Moon, not visible, daytime event.

25th Occultation of Venus by the Moon, not visible from Australia. Venus can be seen a few degrees above the crescent Moon on rising (see Sky View).

25th Moon at perigee (closest to Earth – 363,732 km distant, angular size 32.4').

28th New Moon.

APPEARANCE of the PLANETS



THE PLANETS

MERCURY is in an excellent position for morning observers during April. Mercury rises two hours ahead of the Sun, providing ample opportunity to view this sometimes-elusive planet in a dark sky. Mercury is at its greatest elongation west of the Sun (28°) on the 9th, this is the maximum possible angular distance the planet can be from the Sun. On the 26th, the slender crescent of the 27-day old is around 5° above and north of Mercury (see Sky View).

VENUS, in Capricornus, begins the month high in the eastern morning sky above Mercury. Venus and Uranus appear 0.7° apart on the 18th, and on the following morning a little closer at 0.6°. Binoculars will assist in seeing Uranus from suburban skies. On the 25th, the 26-day old crescent Moon is directly below Venus (see Sky View).

MARS is in Taurus in the evening western sky. Early in the month it is situated directly between the stars Zeta (ζ) and Beta (β) Tauri, the two stars marking the tips of the bull's horns. The planet spends April crossing the Milky Way and moves into Gemini mid-month. On the 17th, the Red Planet is just 0.7° from the heart of M35, a fine open cluster for small to medium sized telescopes.

JUPITER is at opposition next month, and is very noticeable low in the eastern sky after the end of astronomical twilight. On the 15th, the 16-day old Moon appears close to the planet (see Sky View). On the 26th, Jupiter has a temporary new 'moon' as 7th magnitude star SAO158842 passes through the satellite plane.

SHADES OF MESSIER

In Astronomy 2004 we highlighted the life and catalogue of Charles Messier. Even today this 18th century collection is still probably the most famous listing of deep sky objects. We would like to touch on two other more obscure catalogues, Caldwell and Bennett, for both have been inspired by the work of this French astronomer. You will unlikely find designations from these catalogues in star atlases, but these and the Messier numbers are great compilations of objects to suit the beginner. Novices should therefore remember to look for the other designations for the objects (mostly NGC or IC) on maps. Sometimes the Messier numbers may be missing as well, but you will find we have given the M numbers preference in our All Sky Maps in this publication.

Caldwell Catalogue

This collection was compiled by the famous 20th / 21st century English astronomy populariser, Sir Patrick Moore. His complete surname is Caldwell-Moore so using Caldwell generates 'C' numbers as opposed to 'M', which had already been claimed by Messier. It is a listing of brighter deep sky objects which Messier did not include in his list. Unlike Messier, who stuck mainly to northern objects, it covers the whole sky. The numbering system is a little unique, being arranged in order of declination, e.g., C1 is an open star cluster in Cepheus (NGC 188 at declination +85°), down to C109 (a planetary nebula NGC 3195 in Chamaeleon at −80°). In general the Caldwells are visible through most modest amateur telescopes, if not binoculars. It is interesting to note Sir Patrick chose to select the same number of objects as Messiers. It is a restriction that was probably unnecessary and when looking at its members, particularly in the far south, one could debate why some were included ahead of others. For example there are three globular clusters listed with magnitudes fainter than 10, but the brilliant Carina globular NGC 2808, at magnitude 5.7, has been excluded!

Amateurs the world over seem to have a love-hate attitude towards Mr Moore. And it has been said that we don't need Sir Patrick to point out to us in the south, the magnificent objects we have grown up with — let alone renaming them! However, to offer an olive branch, many beginners may appreciate lists such as this and besides, who hasn't grown up with at least one of his publications on their bookshelves. The catalogue can be found at:

www.astroleague.org/al/obsclubs/caldwell/cldwlist.html or
www.seds.org/messier/xtra/similar/caldwell.html

Bennett Catalogue

John (Jack) Bennett (1914–1990) was a dedicated amateur astronomer and from the late 60s, for nearly 20 years, patrolled the night sky from South Africa with his 5 inch refractor. His main interest was searching for comets and, like Messier, compiled his own impressive catalogue of deep sky objects that could be mistaken as comets. He even referred to his work as 'Shades of Messier', however his list was a little different to Charles'. Messier's list includes many distinctive open star clusters, like M7 in Scorpius, that could never be mistaken for a cometary visitor to our Sun. Jack's list comprised 152 deep sky objects of which

***Comet Bennett (1969 Y1)**, reached naked-eye brilliance from February to May 1970, peaking around magnitude zero at its perihelion in March. In April it put on an impressive performance when it displayed a split tail spanning 20 to 30 degrees of sky. It has been compared to Hale Bopp (1997) and is considered to be one of the great comets of the 20th Century. Taken by Robert Price on 13th March 1970.*

84% are galaxies, globular clusters and nebulae, which can be easily taken for comets without tails, given poor observing conditions.

It is also interesting that Bennett only included objects south of the celestial equator, i.e., with negative declinations, although from South Africa (like Australia) he would have seen well into the north. Perhaps this restriction helped him avoid having to deal with the multitude of bright galaxies in the Virgo/Coma Berenices cluster. It would not be surprising if he avoided these areas of the sky when searching. He had remarked that he avoided the Large Magellanic Cloud, with all its comet-like objects. The constellations which are richest in Bennett objects are Sagittarius and Ophiuchus. Bennett once wrote, "The constellations Scorpio [sic], Ophiuchus and Sagittarius contain a bewildering variety of comet-like objects. These are mostly globular clusters and all except the largest defy attempts to distinguish them from tailless comets. This relatively small area of sky contains about a third of all the comet-like objects visible with small telescopes south of the equator".

Jack not only discovered two comets, but during one of these search sessions he happened upon the spiral galaxy M83. Knowing the field so well, he immediately noticed a 'new' star, making him the first amateur astronomer in history to visually discover a supernova!

The following site gives a list of the Bennett Catalogue, along with links to images of a number of the objects:

www.astrosurf.com/antilhue/Bennett.htm

SATURN, in retrograde motion since last December, returns to its west to east motion against the star field early this month. This reversal points the planet back toward the open cluster M44, and another close approach occurs in late May. The planet, in Cancer, can be seen high in the northern sky at the end of astronomical twilight.

URANUS, in the early morning sky in Aquarius, is paid a visit by Venus (see above). The planets come as close as 0.3°, but this occurs before they rise.

NEPTUNE has an uneventful month in the morning sky in Capricornus.

PLUTO, approaching opposition in June, rises in the mid-evening eastern sky.

MINOR PLANETS at opposition this month include: 230 Athamantis on the 17th at magnitude 10.6 in Virgo, 354 Eleonora on the 19th at magnitude 10.2 in Bootes and 30 Urania on the 27th at magnitude 11.0 in Virgo.

COMETS

Comet C/2004 B1 (LINEAR) is rising around midnight during April and should be about 10th magnitude. On April 7th it is within a degree of Beta Capricorni. Mid-month sees LINEAR move into Aquila.

Comet 71P/Clark is rising mid-evening during April, but is best observed after midnight. Expected to brighten from 13th to 12th magnitude, Clark moves from Ophiuchus into Sagittarius during the month. On April 16th, the comet passes between M20 and M21. On April 26th, less than a degree separates the comet and M28. As the month ends, comet Clark will be within 2 degrees of M22.

Comet 73P/Schwassmann-Wachmann 3-B moves through Bootes and Corona Borealis this month, and its apparent separation from the below fragment C will continue to increase. Rising mid-evening, the comet could brighten from 12th to 8th magnitude by the end of April.

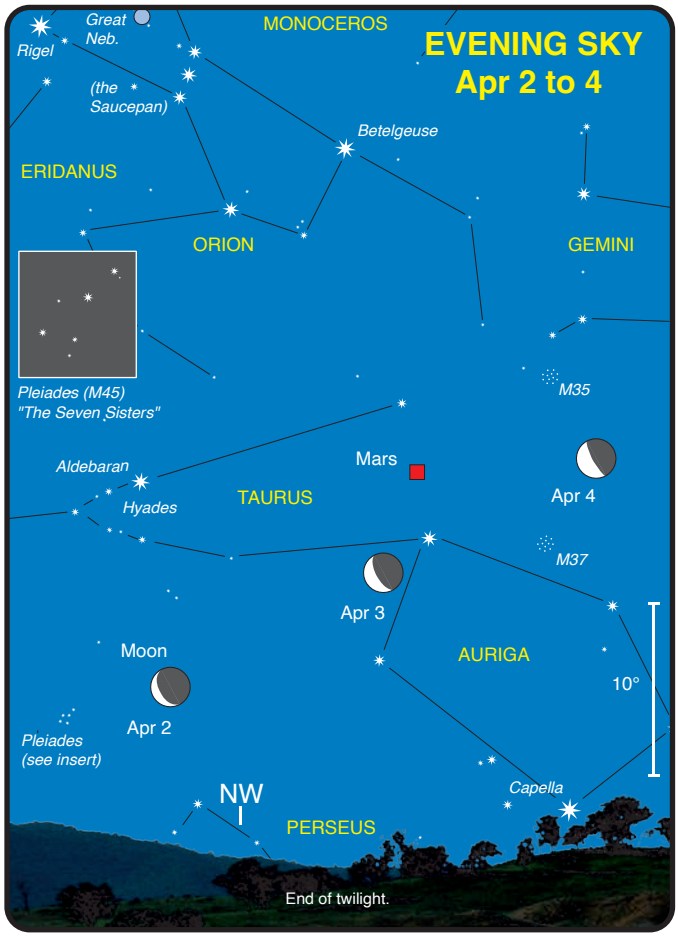
Comet 73P/Schwassmann-Wachmann 3-C, a month away from closest approach to Earth, could be visible to the naked-eye by keen-sighted observers by month's end. Moving northeast through Bootes and Corona Borealis, the comet is rising mid-evening and visible for the rest of the night. It may brighten from 8th to 4th magnitude by month's end. See finder on page 39.

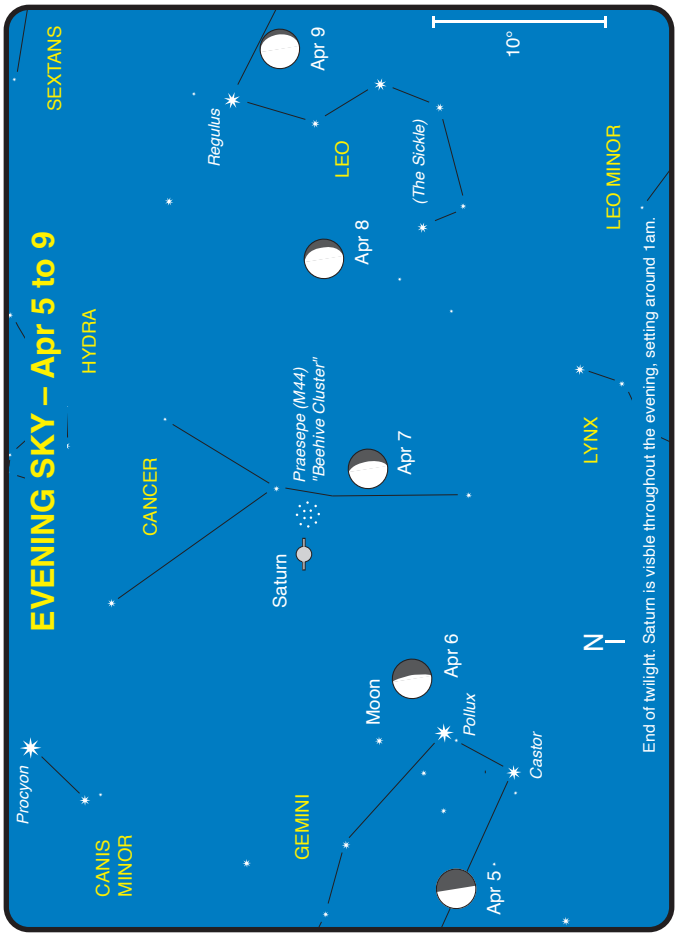
METEOR SHOWERS

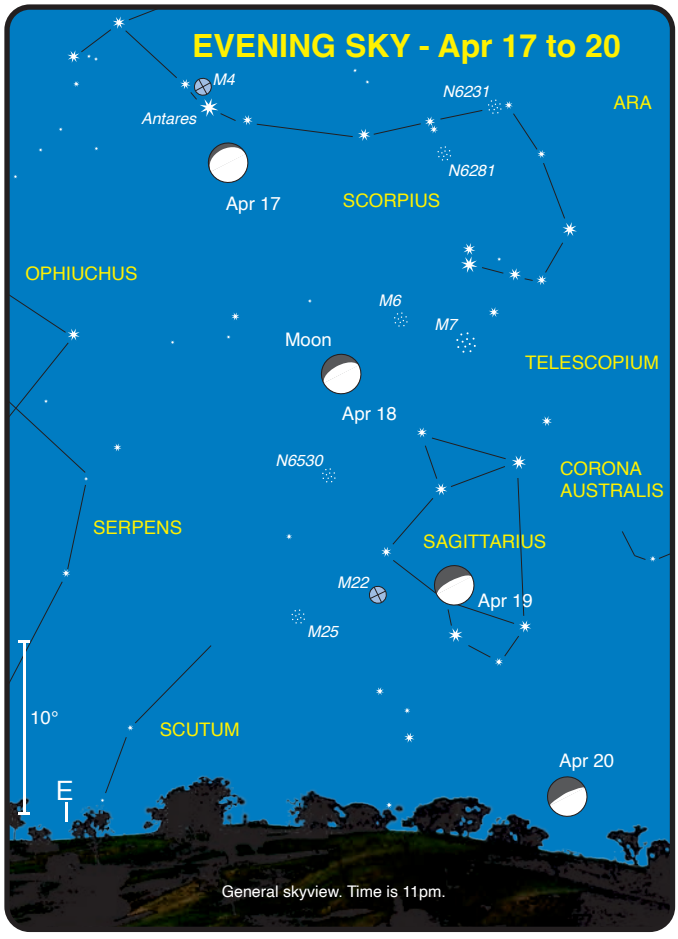
The **pi-Puppids** are a young southern shower first observed in 1972, and produced by Comet 26P/Grigg-Skjellerup. They are best seen from 15th to 28th April, with maximum activity on the 23rd. Leading up to and after maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil, occasionally three to four per hour or more (40 in 1977 and 1982, 13 in 1983). The Pi Puppids are noted for their very slow speed, brightness, persistent trains, large proportion of yellow meteors and occasional fireballs. Conditions for the pi-Puppids this year are excellent. They are best seen prior to local midnight, before the radiant becomes too low, without any interference by the Moon (New Moon is on 28th).

DIARY

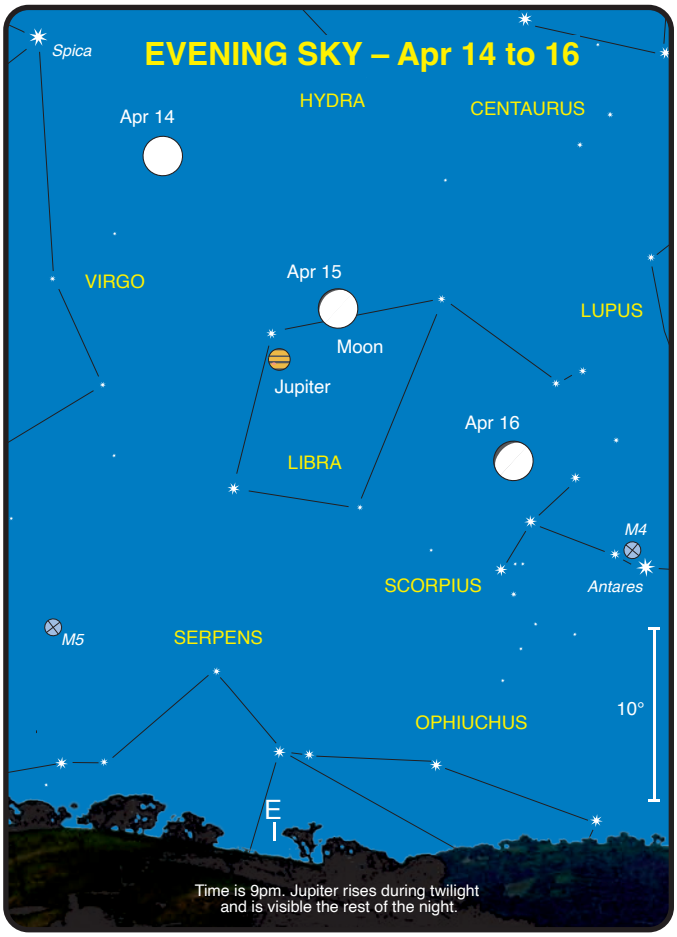
3rd		m.p. 3 Juno 0.9°S of NGC 2169 (OC) in Orion
4th	6am	(4am WST) Mars 4°S of Moon
5th		m.p. 3 Juno 0.5°NW of NGC 2194 (OC) in Orion
5th	10pm	(8pm WST) Saturn stationary
5th	10:01pm	(8:01pm WST) First Quarter
7th	9am	(7am WST) Saturn 4°S of Moon
7th		Comet C/2004 B1 (LINEAR) 0.6°SW of star Beta 1 Capricorni
7th		Mercury at aphelion
9th	5am	(3am WST) Mercury greatest elongation West (28°)
9th	11pm	(9pm WST) Moon at apogee
10th	pm	Comet 71P/Clark 0.4°N of NGC 6469 (OC) in Sagittarius
11th	pm	m.p. 40 Harmonia 0.4°S of NGC 3489 (LG) in Leo
12th		Venus at descending node
14th	2:40am	(12:40am WST) Full Moon
14th	3am	(1am WST) Spica 0.3°S of Moon Occn.
15th	pm	Comet 71P/Clark 0.4°N of M20 (Trifid Neb.) in Sagittarius
16th	1am	(11pm WST, prev day) Jupiter 5°N of Moon
16th	pm	Comet 71P/Clark 0.3°S of M21 (OC) in Sagittarius
17th		Mars 0.7°N of M35 (OC) in Gemini
17th	7pm	(5pm WST) Antares 0.2°N of Moon Occn.
18th	10pm	(8pm WST) Venus 0.3°N of Uranus
19th		m.p. 1 Ceres 0.8°N of star Zeta Capricorni
20th		m.p. 3 Juno 2°S of star Gamma Geminorum
21st	1:28pm	(11:28am WST) Last Quarter
22nd		Jupiter 1.1°NE of star Alpha Librae
22nd	7pm	(5pm WST) Neptune 4°N of Moon
22nd	pm	Comet 73P/Schwassmann-Wachmann 3-C 0.8°SE of star Beta Coronae Borealis
24th		Mercury 0.4°NW of m.p. 97 Klotho
24th	Noon	(10am WST) Uranus 1.2°N of Moon Occn.
24th	Midnight	(10pm WST) Venus 0.5°N of Moon Occn.
25th	9pm	(7pm WST) Moon at perigee
26th	6pm	(4pm WST) Mercury 4°S of Moon
26th	pm	Comet 71P/Clark 0.5°N of M28 (GC) in Sagittarius
28th	5:44am	(3:44am WST) New Moon
28th		Mercury at greatest latitude South
28th	pm	Comet 71P/Clark 0.7°N of star Lambda Sagittarii
29th	pm	Comet 71P/Clark 0.6°N of NGC 6638 (GC) in Sagittarius

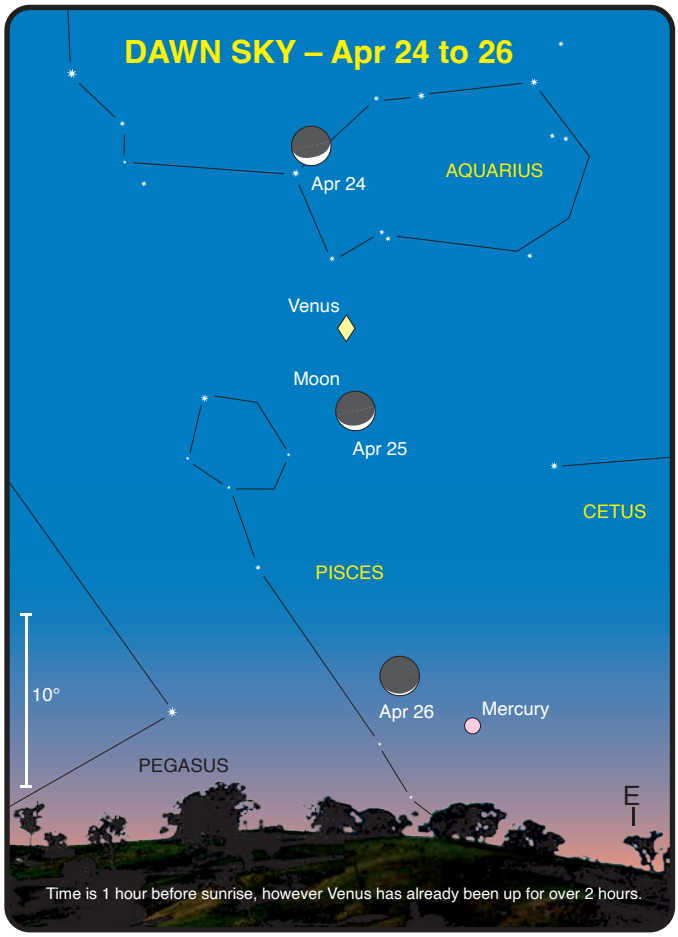






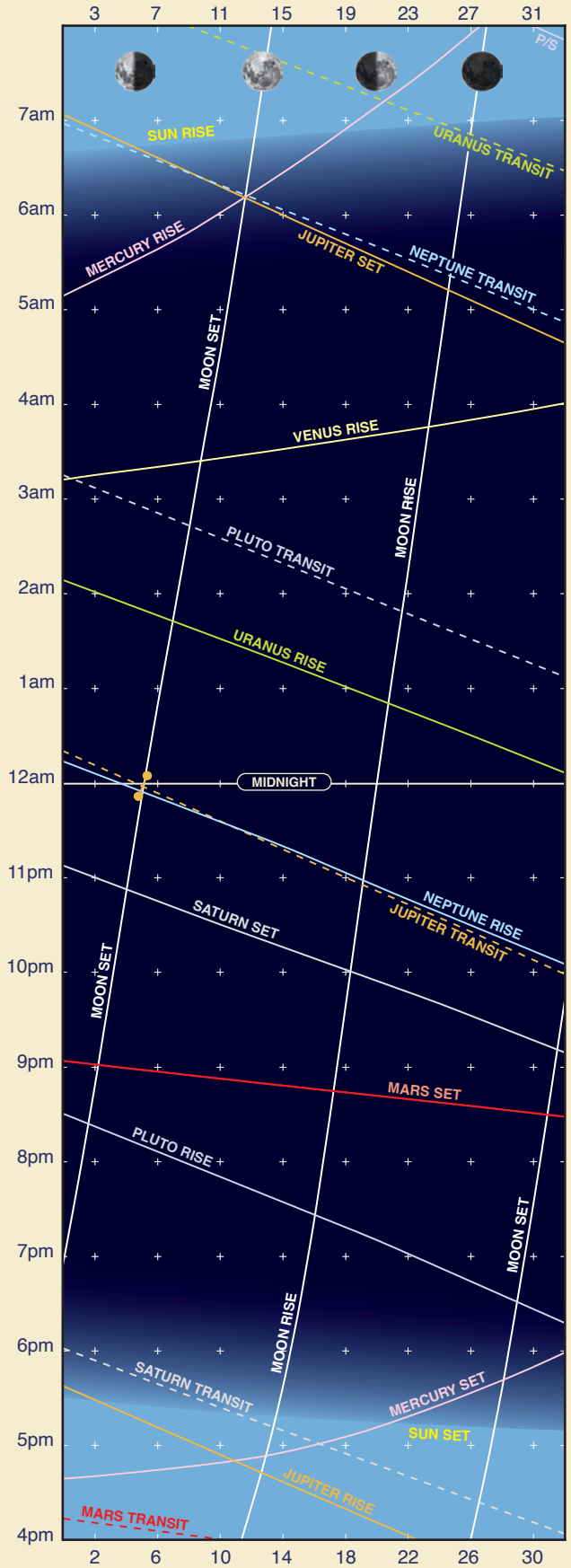
Approximate local standard time.





MAY

RISE/SET CHART



HIGHLIGHTS

- Jupiter at opposition.
- Saturn very close to the open star cluster M44.
- Occultation of Antares by the Moon.
- The eta-Aquarids meteor shower.
- Both components of Comet 73P/Schwassmann-Wachmann 3 make their close approach to Earth. Fragment C may be a naked-eye object.

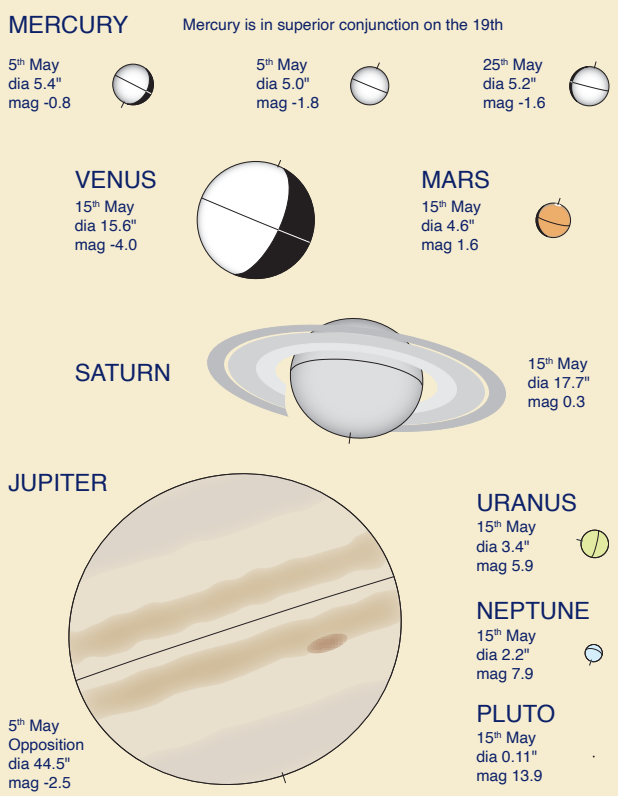
THE MOON

5th	First Quarter.
7th	Moon at apogee (furthest from Earth – 404,572 km distant, angular size 29.8').
11th	Occultation of Spica by the Moon, not visible from Australia.
13th	Full Moon.
15th	Occultation of Antares by the Moon. A late night occultation visible from Australia and New Zealand. See the occultation tables in Part II for times for various Australian capital cities.
20th	Last Quarter.
21st	Occultation of Uranus by the Moon, not visible from Australia.
23rd	Moon at perigee (closest to Earth – 368,608 km distant, angular size 32.4').
27th	New Moon.
31st	Occultation of minor planet Vesta by the Moon, not visible from Australia.

THE PLANETS

MERCURY's favourable position in the morning sky comes to an end as the planet moves into superior conjunction with the Sun (Mercury and Earth on opposite sides of the Sun) on the 19th. Aside from the first week of May, Mercury is effectively lost from view until its reappearance in the evening sky in June.

APPEARANCE of the PLANETS



VENUS is dominant in the morning sky, rising around 3am. On the 24th, the 26-day old thin crescent Moon appears around 6° above and north of the planet (see Sky View). With the exception of a short cut across Cetus for a few days, Venus remains within the boundaries of Pisces during the month.

MARS sets around 9pm mid-month in the western evening sky, with the planet in Gemini until the last day of the month, when it crosses over into Cancer. On the 2nd, the 5-day old crescent Moon appears near the Red Planet (see Sky View) and on the 31st, the 4-day old Moon again is nearby (see Sky View on p. 44).

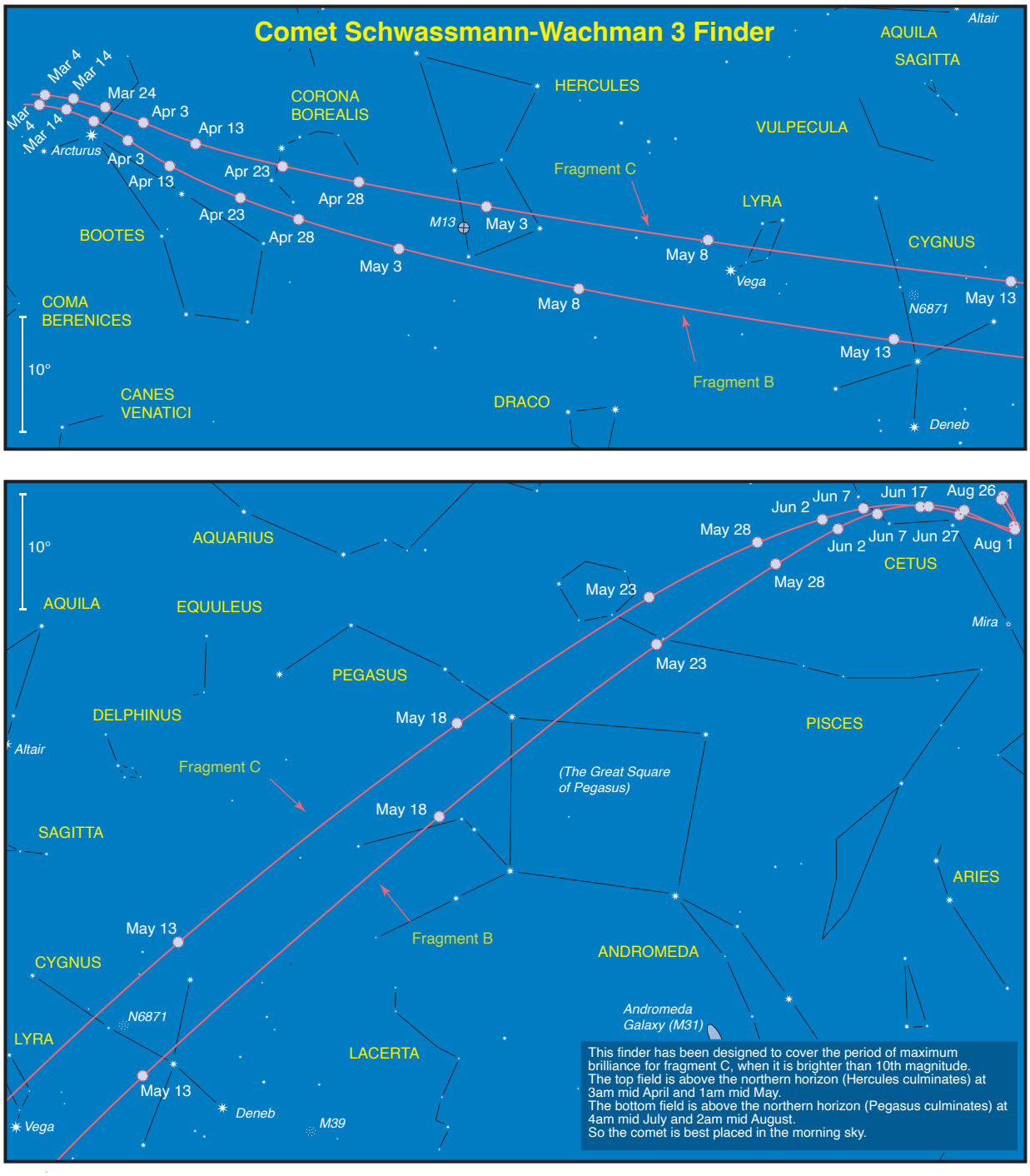
JUPITER is at opposition on the 5th and can be viewed the whole night. It is in Libra and is visible in the east as the sky darkens after sunset. Jupiter was only at aphelion (the most distant point in its orbit from the Sun) in April last year. At this year's opposition the diameter of the planet's disc only reaches 44.6 arc seconds, compared with 50 arc seconds when Jupiter is at perihelion (closest to the Sun). Jupiter's distance from the Sun from perihelion to aphelion varies by around 0.5 AU, equivalent to half the average distance from the Earth to the Sun. The next perihelic opposition occurs in six years time on 29th October 2011. Even though this opposition is not the most favourable, the planet's large angular size ensures even the smallest of telescopes can glimpse the cloud bands, polar flattening and moons at any time. On the 12th, the almost Full Moon appears near Jupiter (see Sky View).

SATURN is in the northwest evening sky, setting around 10pm. It moves slowly through Cancer towards the open star cluster M44, and by month end is situated at the outer boundary of this well-known object. On the 4th, the near First Quarter Moon can be seen just below the planet (see Sky View).

URANUS in Aquarius rises around 1am.

NEPTUNE in Capricornus rises around 11pm. From late this month until the end of October the planet will be in retrograde motion.

PLUTO, nearing opposition mid-June, rises in the early evening eastern sky in Serpens.



MINOR PLANETS. Three of the brighter minor planets reach opposition this month in Libra. They are: 27 Euterpe on the 3rd at magnitude 10.2, 196 Philomela on the 15th at magnitude 10.7 and 8 Flora on the 19th at magnitude 9.6. Others at opposition include 52 Europa on the 3rd at magnitude 10.8 in Virgo and 63 Ausonia on the 2nd at magnitude 10.0 on the border of Libra and Hydra.

COMETS

Comet C/2004 B1 (LINEAR) moves northwest through Aquila and Hercules this month. Still at around 10th magnitude, the comet passes through perigee (1.3 AU) mid-month. By the end of May, LINEAR is rising mid-evening.

Comet 41P/Tuttle-Giacobini-Kresak should brighten this month from 13th to 11th magnitude as it moves eastward through Gemini and Cancer. On May 10th, the comet passes less than three degrees south of Pollux (Beta (β) Geminorum). Setting mid-evening, the comet is best observed at the end of evening twilight. The brightness predictions are given with caution, as Tuttle-Giacobini-Kresak has shown several prominent outbursts in recent returns.

Comet 71P/Clark arcs southeast through the Teapot asterism of Sagittarius this month. Expected to brighten from 12th to 11th magnitude, the comet is rising early in the evening. On May 9th the comet is near Phi (φ) Sagittarii and on May 19th it is near Zeta (ζ) Sagittarii.

DIARY

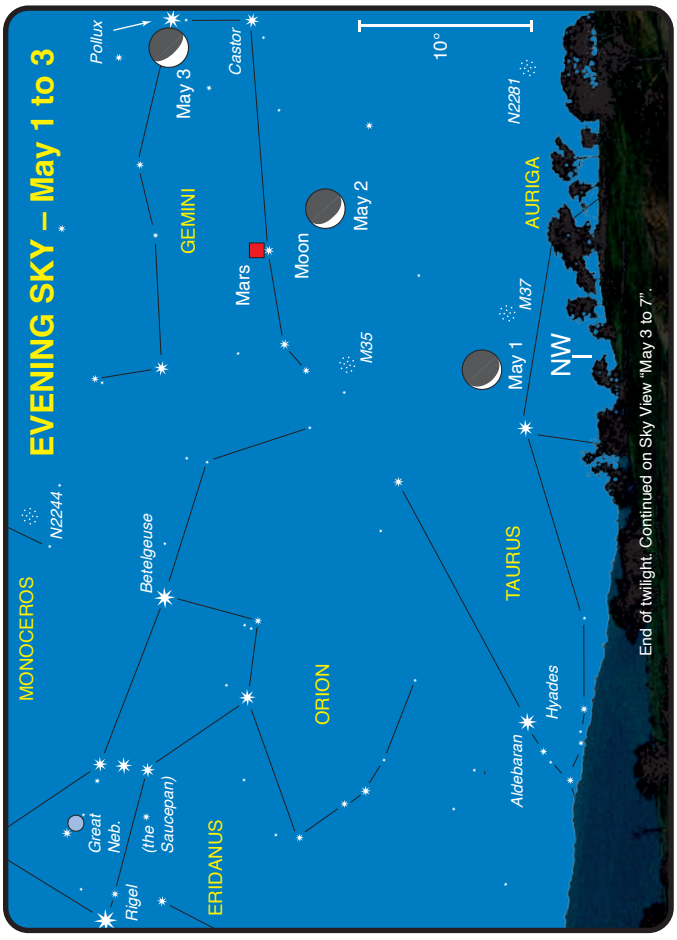
1st		Mars 0.5°S of star Epsilon Geminorum
2nd	9pm	(7pm WST) Mars 4°S of Moon
3rd	1pm	(11am WST) m.p. 2 Pallas stationary
4th	7pm	(5pm WST) Saturn 4°S of Moon
5th	1am	(11pm WST, prev day) Jupiter at opposition
5th		m.p. 25 Phocaea 1.0°SE of star Epsilon Pegasi
5th	3:13pm	(1:13pm WST) First Quarter
6th		Comet C/2004 B1 (LINEAR) 1.0°NE of star Delta Aquilae
7th		m.p. 349 Dembowska 0.1°N of M30 (GC) in Capricornus
7th	5pm	(3pm WST) Moon at apogee
9th	pm	Comet 41P/Tuttle-Giacobini-Kresak 0.7°N of m.p. 4 Vesta
10th	8pm	(6pm WST) m.p. 4 Vesta 0.3°N of star Kappa Geminorum
11th	10am	(8am WST) Spica 0.3°S of Moon Occn.
11th		m.p. 3 Juno 1.2°N of NGC 2355 (OC) in Gemini
11th	pm	Comet 71P/Clark 1.1°SW of star Sigma Sagittarii
13th	2am	(Midnight WST, prev day) Jupiter 5°N of Moon
13th		m.p. 97 Klotho 0.8°N of NGC 474 (LG) in Pisces
13th	4:51pm	(2:51pm WST) Full Moon
14th	2am	(Midnight WST, prev day) Comet 73P/Schwassmann-Wachmann 3-B 0.8°E of M29 (OC) in Cygnus
14th		m.p. 39 Laetitia 0.1°E of NGC 676 (SG) in Pisces
15th	1am	(11pm WST, prev day) Antares 0.1°N of Moon Occn.
15th		m.p. 97 Klotho 0.9°SE of NGC 488 (SG) in Pisces
15th	pm	Comet C/2004 B1 (LINEAR) 0.5°E of NGC 6738 (OC) in Aquilae
16th		m.p. 3 Juno 1.3°N of NGC 2395 (OC) in Gemini
17th		m.p. 9 Metis 0.3°NE of NGC 3377 (EG) in Leo
17th		Venus at aphelion
17th		Mercury at ascending node
19th	6am	(4am WST) Mercury in superior conjunction
19th		Mars at greatest latitude North
19th	pm	Comet 71P/Clark 1.0°NE of star Zeta Sagittarii
20th	1am	(11pm WST, prev day) Neptune 4°N of Moon
20th	7:21pm	(5:21pm WST) Last Quarter
21st		Mercury at perihelion
21st	8pm	(6pm WST) Uranus 1.0°N of Moon Occn.
22nd		m.p. 9 Metis 0.3°NE of NGC 3412 (LG) in Leo
23rd	1am	(11pm WST, prev day) Moon at perigee
23rd	3am	(1am WST) Neptune stationary
24th	6pm	(4pm WST) Venus 4°S of Moon
25th	3pm	(1pm WST) Mars 5°S of Pollux
27th		m.p. 97 Klotho 0.4°NW of NGC 676 (SG) in Pisces
27th	3:26pm	(1:26pm WST) New Moon
28th	am	m.p. 1 Ceres 0.4°SW of NGC 7184 (SG) in Aquarius
30th		m.p. 704 Interamnia 0.4°E of star Alpha Aquarii
31st	1pm	(11am WST) Mars 3°S of Moon
31st	10pm	(8pm WST) m.p. 4 Vesta 0.9°S of Moon Occn.

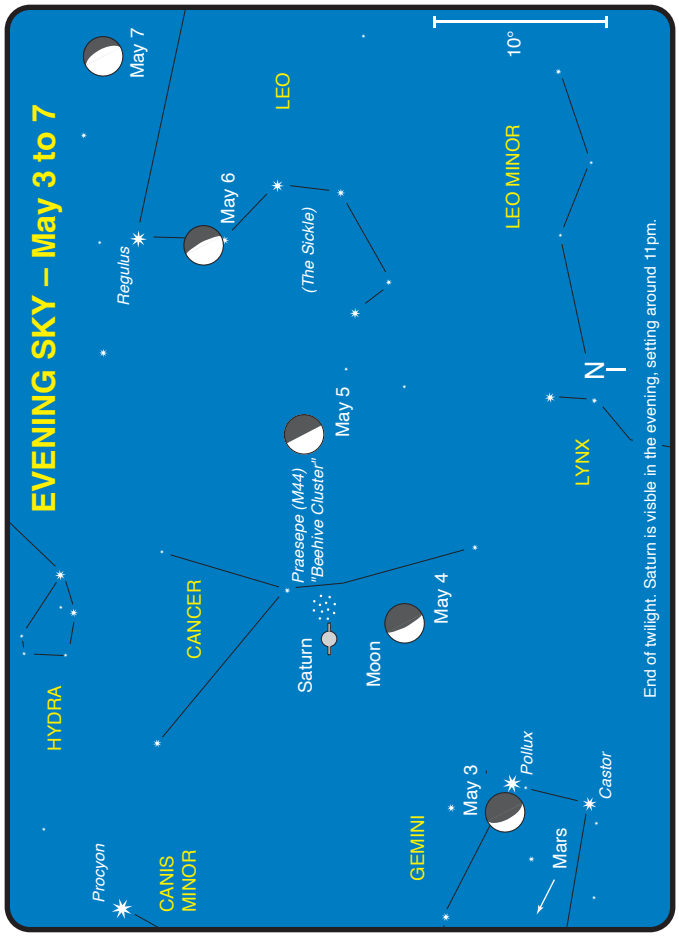
Comet 73P/Schwassmann-Wachmann 3-B, like its brighter companion below, passes very close to Earth this month. The comet begins May, perhaps at 8th magnitude, in Corona Borealis (rising around 9pm) and moves quickly into Hercules. On May 7th the comet is around 2° south of the globular M92. A week later, having passed through Lyra and now found in Cygnus, the comet makes its closest approach, less than 0.07 AU from Earth. At this time, the comet may be around 6th magnitude, and slightly more than 10 degrees from fragment C. The comet moves into Pegasus around mid-month and into Pisces, passing near Omega (ω) Piscis around May 23rd. By month's end, the comet is in Cetus, rising around 2am, at perhaps 7th magnitude. Its separation from fragment C is closing.

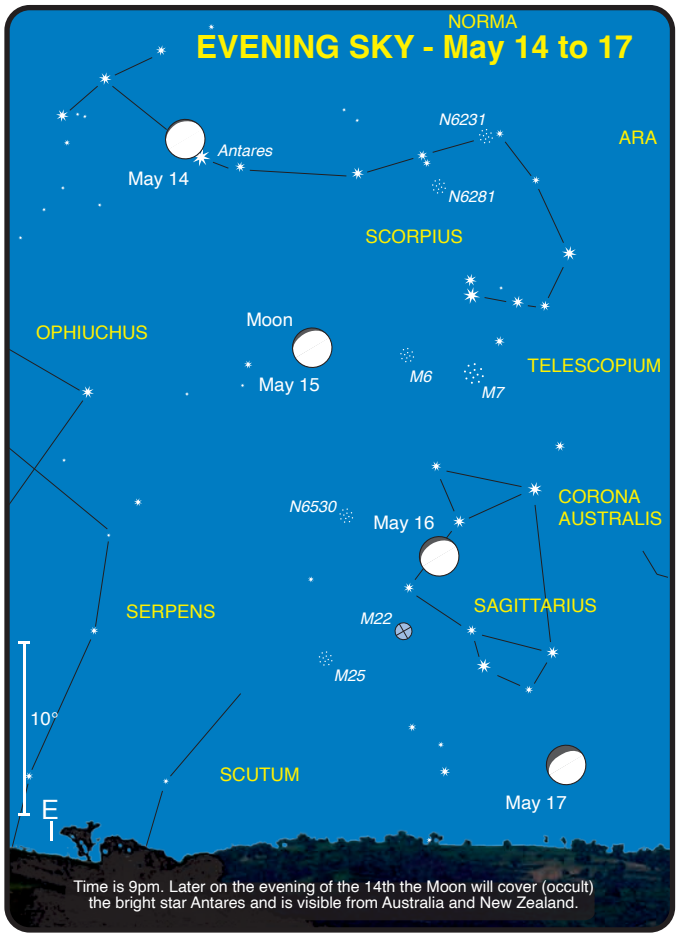
Comet 73P/Schwassmann-Wachmann 3-C (see previous page) commences May rising mid-evening in Hercules. It makes its closest approach to Earth this month, and in the process could brighten to 2nd magnitude. Beginning May at 4th magnitude, the comet moves east through Hercules, passing less than 3 degrees south of the globular M13 on May 2nd. By May 8th, the comet has moved into Lyra and passes south of Vega. Its rapid motion brought about by its proximity to Earth (closest approach of 0.07 AU on May 13th when its peak brightness is expected) sees the comet move quickly through Cygnus and Vulpecula, by which time it's now rising just after midnight. The second half of May sees the comet moving away from Earth, but still approaching perihelion. Moving southeast through Pegasus and Pisces (passing quite close to Iota (ι) Piscis on May 22nd), the comet ends the month in Cetus, still only visible in the morning sky and perhaps still as bright as 3rd magnitude.

METEOR SHOWERS

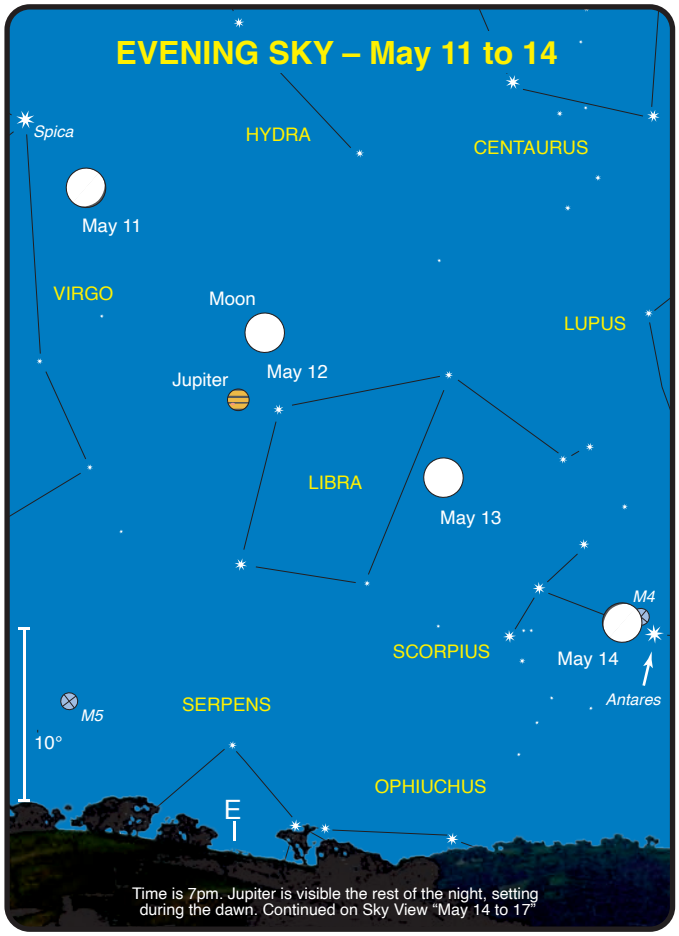
The **eta-Aquarids** are linked with Halley's Comet and rank as one of the most popular of the Southern Hemisphere showers. They are visible for a few hours before dawn from 19th April to 28th May. They peak this month on the 5th, but the rate is generally around 30 for 3–4 days either side of this day. The zenith hourly rate will often reach 50 or more meteors per hour (95 in 1975 and 110 in 1980). The eta-Aquarids are characterised by their high percentage of persistent trains (up to 25% of the meteors). They are very swift and are a striking yellow colour. Conditions are ideal for the Eta Aquarids this year with Moon-free morning skies up to its peak.

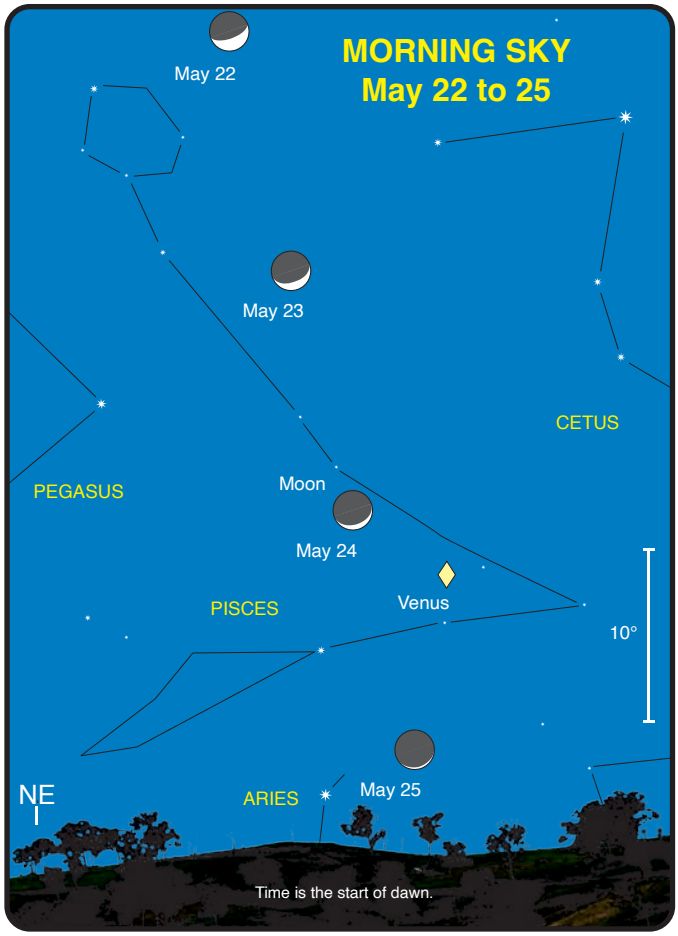






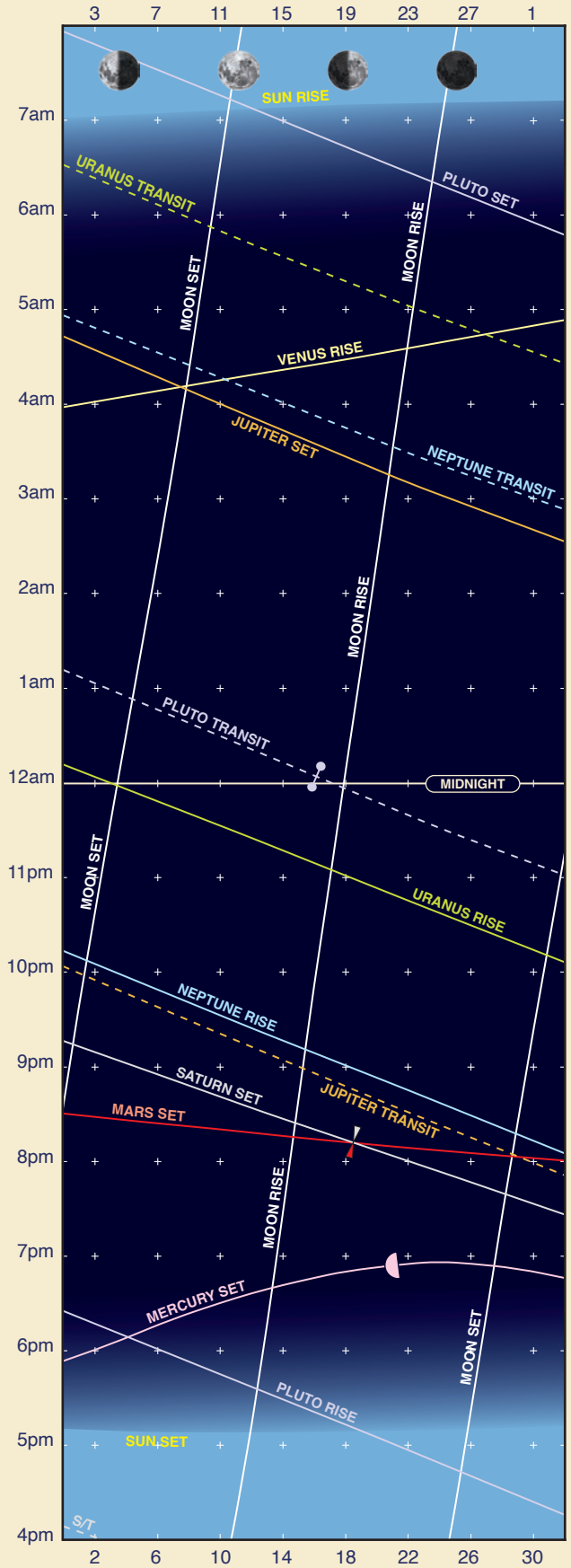
Approximate local standard time.





JUNE

RISE/SET CHART



HIGHLIGHTS

- Spica and Moon close.
- Mercury, Mars, Saturn, Juno, Vesta and Moon all in Cancer.
- Mars crosses M44, the Beehive cluster.
- Mars and Saturn very close.

THE MOON

4th First Quarter.

4th Moon at apogee (furthest from Earth – 404,081 km distant, angular size 29.5').

7th Occultation of Spica by the Moon. Not visible from Australia, however Spica appears quite close to the Moon in the early evening sky (see Sky View).

11th Occultation of Antares by the Moon, not visible from Australia.

12th Full Moon.

17th Moon at perigee (closest to Earth – 368,919 km distant, angular size 32.9').

18th Occultation of Uranus by the Moon, not visible from Australia. From New Zealand the occultation can be observed at the following approximate local times. Auckland: disappearance 4:05am, reappearance 4:35am. Christchurch: d 3:45am, r 4:40am. Wellington: d 3:50am r 4:40.

19th EST (18th WST) Last Quarter.

26th New Moon.

29th Occultation of minor planet Vesta by the Moon, not visible from Australia.

APPEARANCE of the PLANETS

MERCURY

10th Jun
dia 6.6"
mag -0.2

21st Jun
Greatest elongation east
dia 8.2"
mag 0.6

30th Jun
dia 9.8"
mag 1.4

VENUS

15th Jun
dia 13.0"
mag -3.9

MARS

15th Jun
dia 4.2"
mag 1.7

SATURN

15th Jun
dia 17.0"
mag 0.4

JUPITER

15th Jun
dia 42.5"
mag -2.4

URANUS

15th Jun
dia 3.5"
mag 5.8

NEPTUNE

15th Jun
dia 2.3"
mag 7.9

PLUTO

17th Jun
Opposition
dia 0.11"
mag 13.9

THE PLANETS

MERCURY returns to the evening sky this month and reaches its greatest elongation east of the Sun (25°) on the 21st. While not the best of elongations, it still provides an opportunity to see the planet in a dark sky. Typically, this fast moving planet traverses several constellations during the course of a month, beginning in Taurus it quickly crosses over into Gemini and finally into Cancer. On the 27th and 28th, Mercury, Mars, Saturn and the Moon are all in Cancer (see Sky View), and although you will need a telescope to see them, the minor planets Vesta and Juno complete the gathering.

VENUS rises around 4:30am and is located in Aries for the first two weeks of June. It then crosses into Taurus. At month end it will be near the Hyades star cluster and a little under 5° from the 1st magnitude star Aldebaran. The Hyades is a prominent, large naked-eye star cluster that outlines the Bull's Head in Taurus. Aldebaran is not a true member of the cluster but lies between it and our Solar System. Two years have now elapsed since the historical transit of Venus — we trust our readers had clear skies, and a reminder that it's just six years until the next one on 6th June 2012.

V854 Centauri – A Strange Star!

This year marks the twentieth anniversary of the discovery (rediscovery?) of this unusual variable star by one of the authors, Glenn Dawes. It was found during a nova search programme, using a 35mm SLR camera, guided on a tracking equatorial telescope. Long exposures (6 minutes) were typically taken using 400 ASA T Max film through a 55mm lens. Although this equipment was basic, it had a detection limit of around 11th magnitude. These images were certainly deep enough to enable the detection of dozens of known variable stars and minor planets near opposition (see monthly sections for examples).

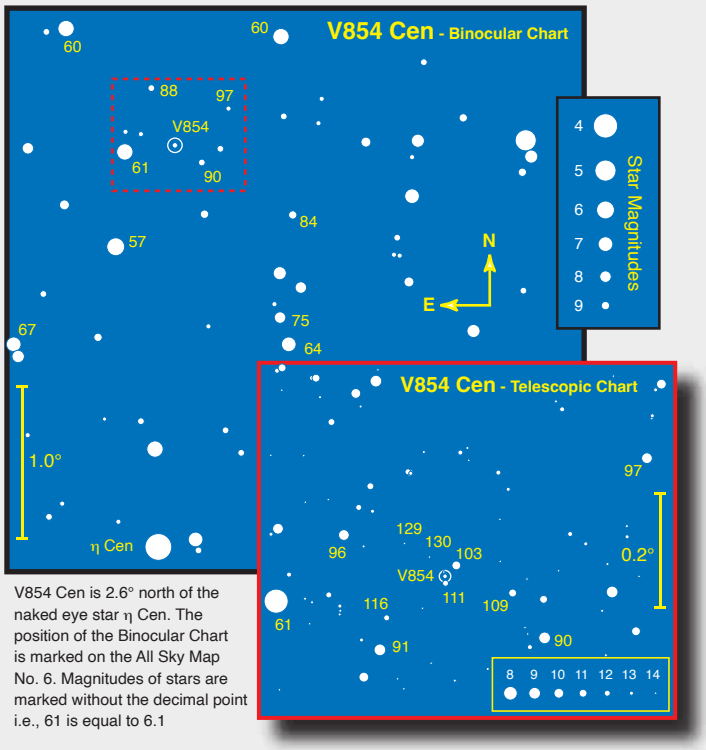
Beginners may be surprised to know that there are tens of thousands of stars known to be variable. By variable we mean the stars change in brightness over a period of time. Most of them behave in a predictable, cyclic manner while others may lay dormant for a while and suddenly flare up or fade. They can be classified into two broad categories. One type of variability is due to internal changes, such as the pulsating Mira stars. Another type involves no internal changes but their drop in brightness is due to a companion periodically passing in front of the star and blocking its light. These are called Eclipsing Binaries. Many thousands of variables have considerable changes in brightness, which are ideal for amateurs to make magnitude estimates and hence graph the changes. There are semi-professional bodies around the world that run observing programmes for selected stars where observers can make meaningful contributions to science.

Returning to V854 Cen, the star was first detected at 7.5 magnitude, with no corresponding object at all on the reference negative of the field taken in late 1985. It was extremely close to the position of a previously suspected variable NSV 6708, but the NSV catalogue showed a range of 9.7 to 10.5, not 7.5 to less than 11th magnitude. An investigation of the star by Robert McNaught at Siding Springs Observatory, Coonabarabran, soon revealed the extraordinary nature of this object.

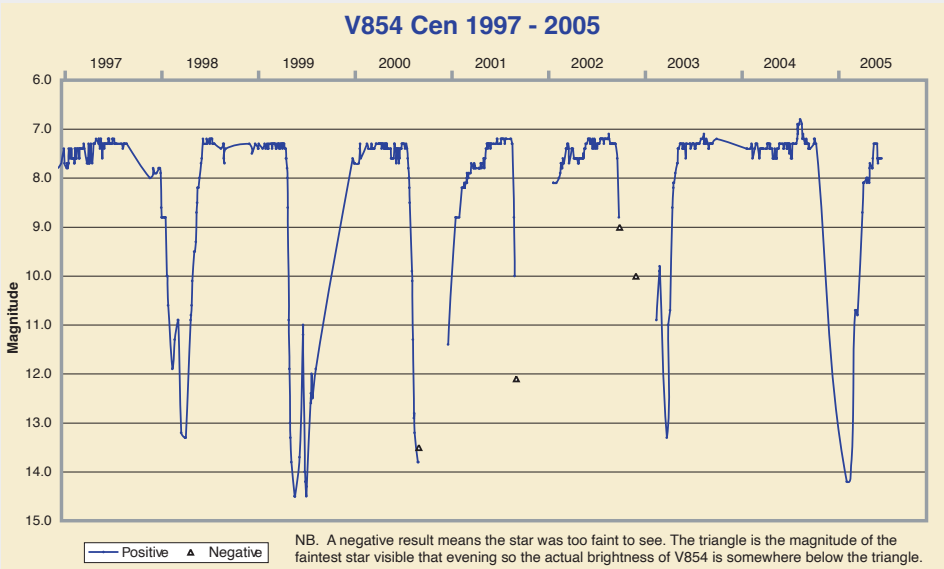
There is a relatively rare type of variable, known as R Coronae Borealis (R CrB) stars, named after the first and brightest example of this class. They spend most of the time at maximum and then fade as they envelop themselves in a cloud of, what can be best described as, soot. They are sometimes called 'the Smokers'. The luminosity drops to its minimum and then recovers in brightness as the carbon concentration drops. It is likely this recovery is due to the star reabsorbing the cloud.

V854 has turned out to be the 3rd brightest example of an R CrB. It is typical for this type of star, having an extreme deep range of brightness from 7th to nearly 15th magnitude! To put this in perspective, imagine if Sirius decided, over a couple of weeks or so, to dim to the point where you would need very dark skies to even glimpse it, if not binoculars! Another way to appreciate this magnitude range is to realise the brighter part of V854's cycle can be easily monitored with a small pair of binoculars. At its faintest you need a 25cm telescope.

Considering V854 Cen's maximum brightness of 7th magnitude it is amazing that it has only been in the last 20 years that its true nature has been determined. The credit for much of the monitoring of the behaviour of this star goes to a handful of amateur astronomers, including Peter Williams in Sydney and Albert Jones in New Zealand, who have continually observed the star since its discovery. An extract from Peter's light curve is shown here. From July 1986 to August 2005 he has made over 1600 magnitude determinations, monitoring some 16 minima during that period. The chart above can be used to make your own estimates of its magnitude.



V854 Cen is 2.6° north of the naked eye star η Cen. The position of the Binocular Chart is marked on the All Sky Map No. 6. Magnitudes of stars are marked without the decimal point i.e., 61 is equal to 6.1



NB. A negative result means the star was too faint to see. The triangle is the magnitude of the faintest star visible that evening so the actual brightness of V854 is somewhere below the triangle.

EARTH is at Solstice on the 21st, when our days are shortest. On this day, the Sun is at its most northerly position with a declination of +23.5°.

MARS sets around 8pm, remaining in Cancer all month. Its path takes it directly toward M44, the Beehive Cluster, and between the 14th and 16th the Red Planet crosses the cluster being near the centre on the 15th (see Sky View). After leaving M44, Mars visits Saturn, and the pair will be at their closest on the 17th and 18th at 0.6° (see Sky View). Although low in the western evening sky, there are some good, aesthetic wide angle imaging possibilities around this entire period. An image of the Beehive region will not only include Mars and Saturn but also the minor planet Vesta, which is 2.5° to the north of Mars at this time.

JUPITER, now past opposition, transits the meridian around 9pm. On the 8th, the 12-day old waxing Moon will be near the planet. Still in retrograde motion the planet moves slowly through Libra during the month. On the 26th, a double star can be seen 5 arc minutes northwest of Jupiter. This 6.5 magnitude star, SAO 158577, and its 7th magnitude companion (separated by 19"), remain within 5 arc minutes of Jupiter until mid-July.

SATURN begins June situated on the outskirts of the Beehive cluster, slowly moving away from the cluster during the course of the month (see Sky View). This is the second time it has visited this large open star cluster in Cancer this year (see also the February monthly text). Faster moving Mars closes in on the Ringed Planet, catching up on the 17th for a close approach (see Mars above, and Sky View). On the 28th, the 3-day old crescent Moon appears nearby Saturn, forming a triangle with Mars (see Sky View p. 48).

DIARY

1st	7am	(5am WST) Saturn 4°S of Moon
1st		Mercury at greatest latitude North
3rd		Saturn 0.8°S of Beehive Cluster (OC) in Cancer
4th	9:06am	(7:06am WST) First Quarter
4th	Noon	(10am WST) Moon at apogee
7th	7pm	(5pm WST) Spica 0.1°S of Moon Occn.
8th		Venus at greatest latitude South
9th	5am	(3am WST) Jupiter 5°N of Moon
11th	9am	(7am WST) Antares 0.1°N of Moon Occn.
12th	4:03am	(2:03am WST) Full Moon
13th		Venus 0.9°NE of m.p. 44 Nysa
15th		Mars 0.3°SW of Beehive Cluster (OC) in Cancer
16th	7am	(5am WST) Neptune 3°N of Moon
16th		m.p. 68 Leto 0.2°NW of NGC 7727 (SG) in Aquarius
17th	3am	(1am WST) Moon at perigee
17th	3am	(1am WST) Pluto at opposition
17th		Comet 41P/Tuttle-Giacobini-Kresak 0.6°N of star Gamma 1 Leonis
18th	3am	(1am WST) Uranus 0.6°N of Moon Occn.
18th	9am	(7am WST) Mars 0.6°N of Saturn
18th		Comet 41P/Tuttle-Giacobini-Kresak 0.3°NE of NGC 3227 (SG) in Leo
19th	12:08am	(10:08pm WST, prev day) Last Quarter
19th		Mars 0.2°NW of NGC 2672 (EG) in Cancer
20th	2am	(Midnight WST, prev day) Uranus stationary
21st	6am	(4am WST) Mercury greatest elongation East (25°)
21st	9am	(7am WST) Mercury 6°S of Pollux
21st	10pm	(8pm WST) Solstice
21st	pm	Comet C/2004 B1 (LINEAR) 1.0°S of star Zeta Herculis
23rd		Venus 6°S of the Pleiades (OC) in Taurus
23rd	1pm	(11am WST) Venus 6°S of Moon
24th		Mercury at descending node
26th	2:05am	(12:05am WST) New Moon
26th		Mars at aphelion
26th	10pm	(8pm WST) m.p. 1 Ceres stationary
27th		m.p. 9 Metis 1.1°SW of NGC 3705 (SG) in Leo
27th	Midnight	(10pm WST) Mercury 5°S of Moon
28th	9pm	(7pm WST) Saturn 3°S of Moon
29th	5am	(3am WST) m.p. 4 Vesta 0.2°N of Moon Occn.
29th	7am	(5am WST) Mars 2°S of Moon
29th		Comet 41P/Tuttle-Giacobini-Kresak 0.8°N of star Theta Leonis
30th		m.p. 3 Juno 1.4°N of M67 (OC) in Cancer

URANUS in Aquarius rises around 11pm. From the 20th, until late November, the planet will be in retrograde motion.

NEPTUNE in Capricornus rises around 9pm.

PLUTO, in Serpens, is at opposition on the 17th and hence is above the horizon the entire night. This distant planet is currently 4,506,000,000 km from Earth (30.1213 AU), its light taking about 250 minutes to reach us.

MINOR PLANETS at opposition this month include 532 Herculina on the 16th at magnitude 9.2 in Serpens and 13 Egeria on the 30th at magnitude 10.8 in Corona Australis.

COMETS

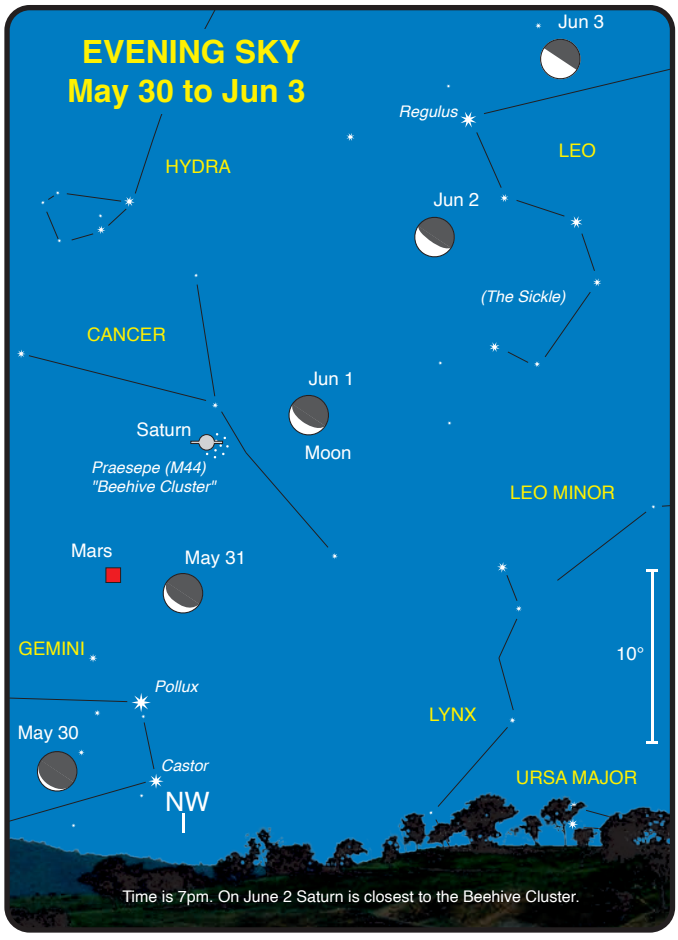
Comet C/2004 B1 (LINEAR) is transiting mid-evening in June as it moves northwest through Hercules and Corona Borealis. Now past perihelion and perigee, the comet should fade from 10th to 11th magnitude.

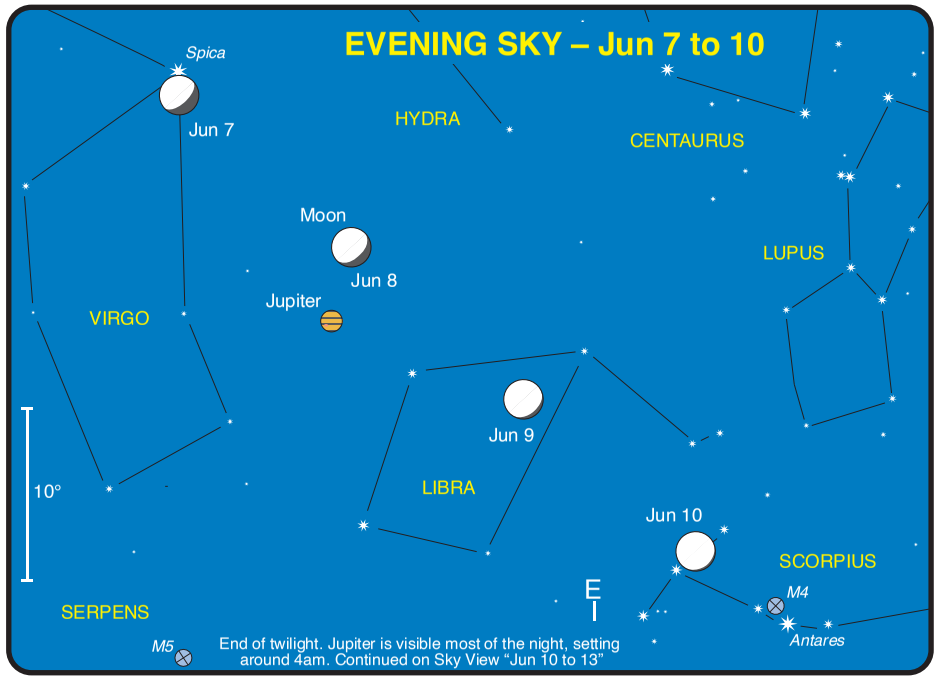
Comet 41P/Tuttle-Giacobini-Kresak reaches perihelion (1.0 AU) this month and should be around 11th magnitude throughout (though note the advice given for May), as it moves through Cancer and Leo. On June 6th, the comet will be near Lambda Leonis, and on June 17th it will pass close to Gamma Leonis. Setting mid-evening, it ends June near Theta Leonis.

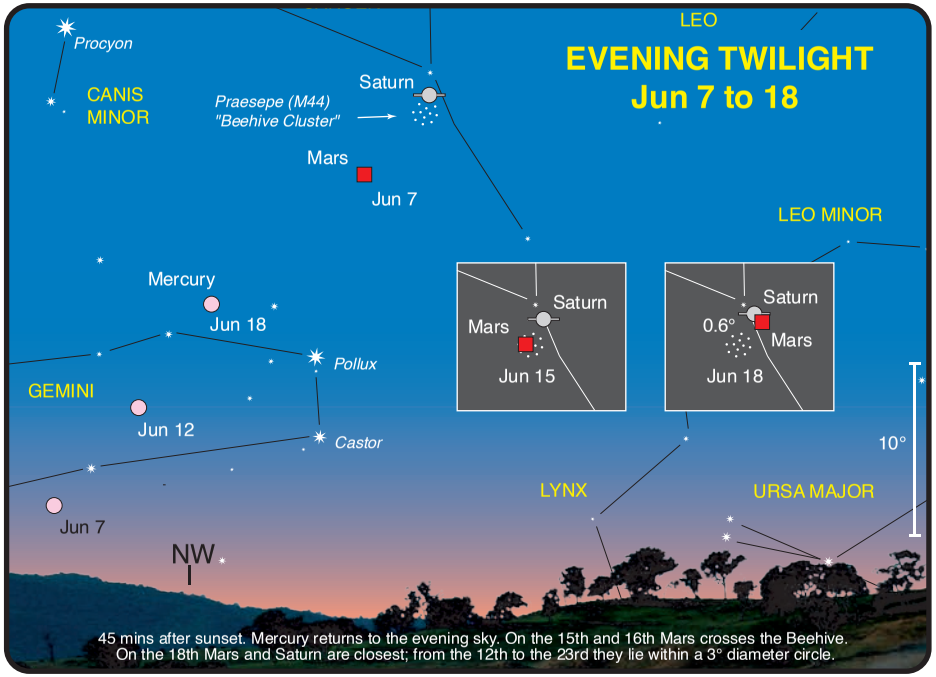
Comet 71P/Clark should remain at 11th magnitude during June as it passes through both perihelion (1.6 AU) and perigee (0.6 AU). Moving southward through Sagittarius, Clark rises early in the night.

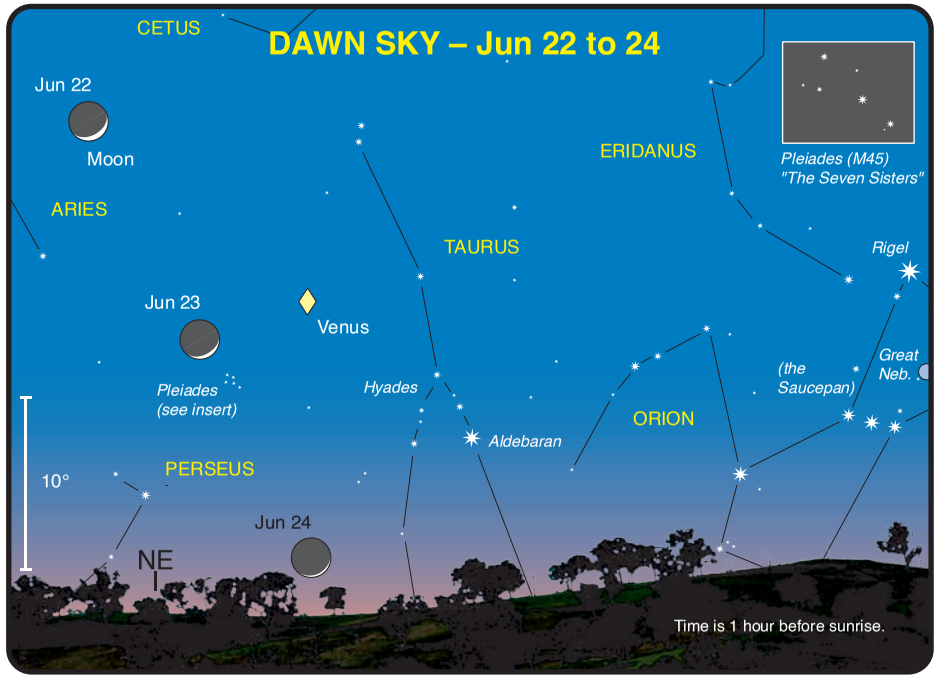
Comet 73P/Schwassmann-Wachmann 3-B is a morning object in Cetus during June. Expected to fade from 7th to 9th magnitude during the month, the comet is at perihelion on June 8th. During the second half of June, the comet will be within a degree of fragment C (see below).

Comet 73P/Schwassmann-Wachmann 3-C should remain a marginal naked-eye sight in June's morning skies. Possibly beginning the month at 3rd magnitude, the comet is moving southeast through Cetus. On June 11th, when the comet is at perihelion (0.9 AU), it is 2 degrees south of Theta Ceti (see also finder on p. 39). By the end of June, the comet may have faded to 6th magnitude.

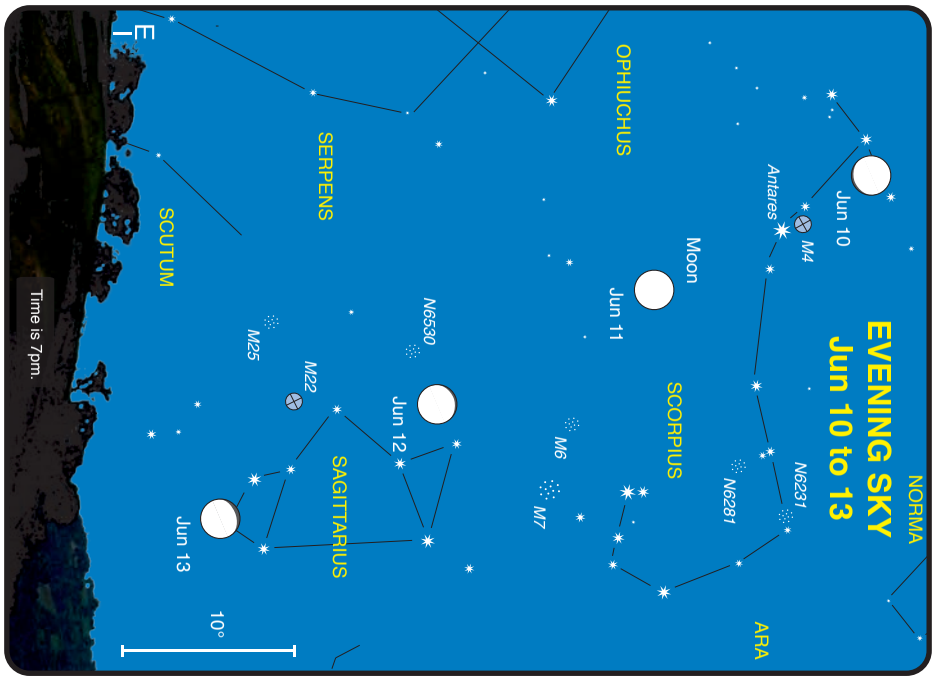






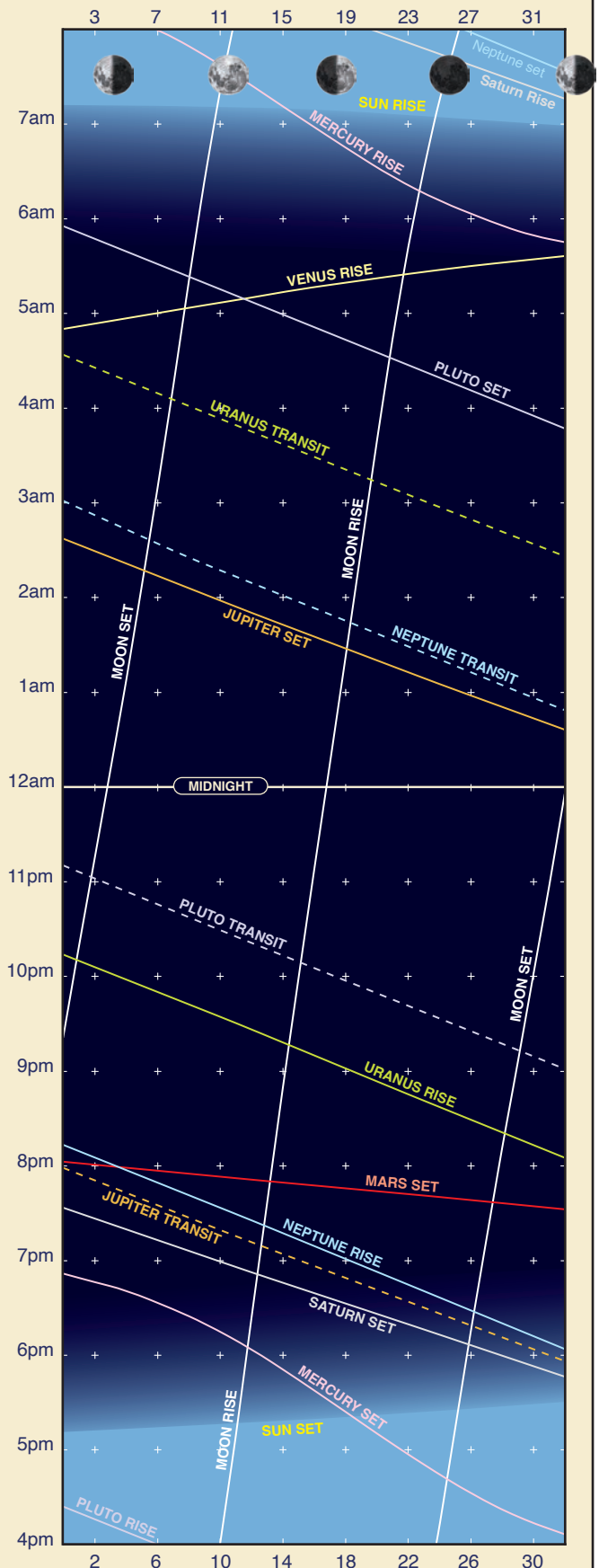


Approximate local standard time.



JULY

RISE/SET CHART



HIGHLIGHTS

- Antares very close to Moon.
- Mars and Regulus very close.
- The Southern delta-Aquarids meteor shower.
- Minor planets 1 Ceres and 349 Dembowska travel together.

THE MOON

2nd Moon at apogee (furthest from Earth – 404,448 km distant, angular size 29.2').

4th First Quarter.

5th Occultation of Spica by the Moon, not visible from Australia.

8th Occultation of Antares by the Moon. This is a daytime event and will be very difficult to see, but who knows? The Moon and Antares are located in a darkening eastern sky and it may be possible to see the occultation/close approach with a telescope, so we provide the following for a bit of a challenge and fun. The occultation is visible north of a line from the southern tip of New Zealand to Darwin. For Brisbane: disappearance 4:27 pm, reappearance 5:17 pm. Darwin: d below horizon, r 4:24 pm. Sydney: d 4:48 pm, r 5:12 pm. Antares appears quite close (no occultation) to the lunar limb at the following approximate local times from Adelaide 4:30 pm, Hobart and Melbourne 5pm. In any event, from across the continent, when it is sufficiently dark, Antares will be quite close to the bright limb (see Sky View).

11th Full Moon.

14th Moon at perigee (closest to Earth – 364,288 km, size 33.3').

15th Occultation of Uranus by the Moon, not visible from Australia.

18th Last Quarter.

25th New Moon.

28th Occultation of Mars by the Moon, not visible from Australia.

29th Moon at apogee (furthest from Earth – 405,406 km distant, angular size 29.3').

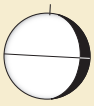
APPEARANCE of the PLANETS

MERCURY Mercury is in inferior conjunction on the 18th

5th Jul
dia 10.7"
mag 2.1

25th Jul
dia 10.6"
mag 3.1

VENUS

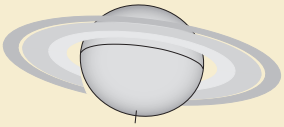


15th Jul
dia 11.5"
mag -3.9

MARS

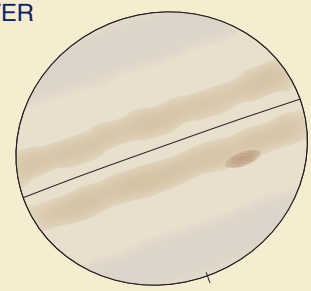
15th Jul
dia 3.9"
mag 1.8

SATURN



15th Jul
dia 16.5"
mag 0.4

JUPITER



15th Jul
dia 39.2"
mag -2.2

URANUS

15th Jul
dia 3.6"
mag 5.8

NEPTUNE

15th Jul
dia 2.3"
mag 7.8

PLUTO

15th Jul
dia 0.11"
mag 13.9

THE PLANETS

MERCURY is visible early in the month in the evening western sky in Cancer. The planet quickly loses altitude as it moves toward inferior conjunction on the 18th (between the Sun and Earth). Mercury then moves west of the Sun and into the morning sky, joining Venus in Gemini.

VENUS, rising around 5:30am, spends the first half of the month in Taurus in the morning eastern sky. The planet passes 0.7° north of M1 (the Crab Nebula), the remnant of the supernova of 1054 AD, on the 14th. Cutting across the lower portion of Orion for a few days, Venus ends up in Gemini with Mercury. Venus and Mercury move closer to each other day by day, and at month end are around 8° apart.

The **EARTH** is at aphelion (the furthest point in its orbit from the Sun) on the 4th. The Earth/Sun distance is 1.016697 astronomical units, which is equivalent to 152,095,912 km. The average distance between the Sun and Earth is 149,597,870 km or 1 AU.

MARS can be seen in the early western evening sky, setting around 8pm. Moving from Cancer into Leo early in July, the planet heads directly toward the 1st magnitude star Regulus (Alpha Leonis). From the 21st to 23rd, the Red Planet will be within 1° of Regulus (see Sky View). Centred directly between Mars and Regulus on the 22nd is Leo I, the Regulus dwarf galaxy. Leo I is a dwarf elliptical galaxy that belongs to our own Local Group of galaxies. It easy to locate just 20 arc minutes due north of Regulus, but is challenging in telescopes under about 30 cm. Although the integrated magnitude is a bright 9.8, its light is spread over a large area, 10 x 8.3 arc seconds, giving an overall low surface brightness. Under dark skies smaller telescopes theoretically would be up to the task, however the light from nearby Regulus tends to overwhelm the galaxy. On the 27th, the 2-day old slender crescent Moon appears around 6° below Mars, and on the following evening a similar distance above (see Sky View).

JUPITER is in an ideal position for evening observation this month, transiting the meridian around 7pm. In retrograde motion since March, Jupiter returns to its west to east motion against the star field. The Moon, just past First Quarter, appears near Jupiter on the 5th and 6th (see Sky View).

SATURN, in Cancer, is visible low in the western twilight sky early in July. The planet then becomes too close to the Sun for observation, as it moves toward solar conjunction early next month. Saturn returns to grace the morning skies in September.

URANUS, in Aquarius, rises around 9pm.

NEPTUNE, in Capricornus, rises around 7pm and is visible the rest of the night. It will be at opposition early in August.

PLUTO, now past opposition, transits the meridian around 10pm. This month provides a good opportunity to locate this faint outer world, as it is near a couple of bright stars (relative to Pluto), but you will need at least a 20cm telescope for this task. The two stars are 3.5 magnitude Xi (x) Serpentis, and 6th magnitude HR6562, and they present an easy to find stepping off point for star hopping to Pluto (see Finder Chart in Part II). Pluto spends the month within 0.5° of naked-eye 3.5 magnitude Xi.

MINOR PLANETS at opposition this month include: 2 Pallas on the 1st at magnitude 9.5 in Hercules, 29 Amphitrite on the 12th at magnitude 9.4 in Sagittarius, 10 Hygiea on the 13th at magnitude 9.2 in Sagittarius and 15 Eunomia on the 30th at magnitude 8.3 in Capricornus.

1 Ceres and 349 Dembowska, both at opposition next month, become travelling companions in July. For the first half of the month they remain within 0.5° of each other — being closest on the 8th.

Lambda Tauri, 39 Laetitia and 97 Klotho form a straight line on the morning of the 31st — fitting within a 1° diameter circle.

THE GREAT MOON HOAX

There is a small percentage of people who believe that NASA faked the Moon landings, and this has become known as the Great Moon Hoax. Amusingly, some 134 years prior to Apollo 11 there was another lunar hoax, this time at the expense of Sir John Herschel. On 25th August 1835 the first instalment of a six part article appeared in *The Sun*, a New York daily newspaper, entitled *Great Astronomical Discoveries Lately Made by Sir John Herschel at the Cape of Good Hope*. With a circulation of 8,000 copies, the two year old fledgling *Sun* would see this figure soar to over 19,000 overnight; such was the intense interest by New Yorkers. The struggling *Sun* became the world's largest selling daily newspaper, eclipsing the London *Times* by 2,000 copies.

The creator of the hoax was Richard Adams Locke, a reporter who had been recently hired by the *Sun*. If it was Locke's intention to drive up sales he certainly achieved that goal. The 11,000-word article was cleverly crafted, and was credited to be from a supplement to the Edinburgh Journal of Science.

In a rambling part one containing much pseudo-science and gibberish, the reader learns how Sir John created a "… telescope of vast dimensions and en [sic] entirely new principle". The 24 foot lens weighed 15,000 lb, and had a magnifying power of 42,000 times. By the use of a hydro-oxygen microscope applied to the telescope, Herschel "expressed confidence in the ultimate ability to study even the entomology of the Moon, in case she contained insects upon her surface".

On the following day, a lengthy description of the new telescope and its workings was provided. We were then told that countless new stars and nebulae had been discovered, and on 10th January 1835 the telescope was turned toward the 11-day old gibbous Moon. It is interesting that this date was chosen, as Jupiter was just emerging from an occultation with the Moon at the exact time; this was not mentioned in the meticulously detailed article. Almost immediately the observers came upon dark red poppy-like flowers, "the first organic production of nature, in a foreign world, ever revealed to the eyes of men".

Under the gaze of our intrepid explorers, the lunar scenery unfolded before them. Forests of trees and green plains, vast seas, and valleys containing claret colour amethysts, 60 to 90 feet high were observed. Towards the end of the second instalment, perhaps not surprisingly, living creatures were found. The first sighting was of herds of brown bison-like quadrupeds, and then bluish-lead coloured sprightly antelope-like animals. A spherical amphibious creature was sighted which rolled at great velocity across a pebbly beach and into the water.

The incredible descriptions of lunar fauna and flora, volcanic landscapes, huge triangular temples and crystal islands continued in painstaking detail throughout the series. Biped beavers that live in huts and use fire were detailed, and flying moon people, four feet high with bat-like wings were discovered. The observers dubbed the humanoids "Vespertilio-homo or man-bat" and as a bit of a tease for the readers, described them thus "they are doubtless innocent and happy creatures, notwithstanding that some of their amusements would but ill comport with our terrestrial notions of decorum".

Word of the articles took many weeks to reach Herschel, and he was at first amused, noting that his own observations could never be as exciting. Amusement turned to annoyance when it was realised that many had taken the hoax seriously. The *Sun* never came clean on the issue, although in September 1835 it did publish an article that discussed the possibility that the narrative was untrue, but it never owned up to any wrongdoing. The entire article can be downloaded at www.museumofhoaxes.com/moonhoax.html

References: The Shadow of the Telescope — Gunther Buttmann
The Book of the Heavens — Mary Proctor

'Moon People with Wings and Fur'
from a drawing published in 1835.

COMETS

Comet C/2004 B1 (LINEAR) slowly moves through Corona Borealis this month. Setting around midnight, the comet reaches the northernmost point of its apparition this month, and is expected to fade from 11th to 12th magnitude.

Comet 4P/Faye is expected to brighten to 13th magnitude by the end of July. Moving northeast through Pisces, comet Faye rises around midnight and is best observed just before dawn.

Comet 41P/Tuttle-Giacobini-Kresak should fade this month from 11th to 14th magnitude (again, look out for any unusual behaviour). It passes through perigee (0.9 AU) early in the month. Tuttle-Giacobini-Kresak, best seen early in the evening, moves southeast through Leo and into Virgo, passing across the Virgo Cluster of galaxies mid-month.

Comet 71P/Clark is visible all night in Sagittarius this month. At 11th magnitude, the comet spends the first half of the month within several degrees of Alpha Sagittarii. At the end of July, Clark reaches the southern most point of its observable passage during this apparition.

Comet 73P/Schwassmann-Wachmann 3-B can be found in the morning sky in July, rising around midnight. Moving through Cetus, the comet might fade from 9th to 11th magnitude. It spends the month within a half of a degree of its companion C (see finder chart p. 39).

Comet 73P/Schwassmann-Wachmann 3-C remains in Cetus through July. Visible in the morning sky, the comet may fade from 6th to 8th magnitude. By month's end, the comet is near Rho Ceti.

METEOR SHOWERS

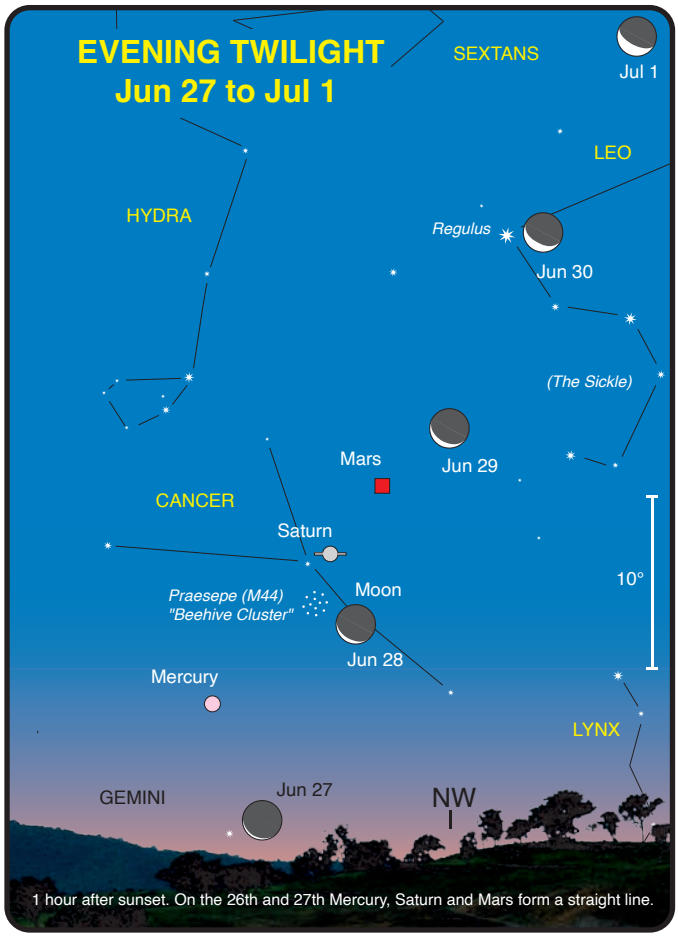
The **Piscis Austrinids** are visible from the 15th July to 10th August. The shower generally provides 1 or 2 meteors per hour and on occasion 3 or 4. The zenith hourly rate increases to 8 or 10 meteors on the 28th, however this can vary from as little as 5 to as many as 15 per hour. Visible from about 8pm to the beginning of morning twilight the Piscis Austrinids are generally blue, white or yellow in colour, with some leaving trains. Conditions are good this year for the peak with New Moon on the 25th.

The **Southern delta-Aquarids** are one of the strongest and most consistent of the southern showers, visible late evening until dawn. The range of activity of these medium speed meteors extends from 12th July through to 19th August, with maximum this month on the 28th, with a zenith hourly rate of 20. The delta-Aquarids are generally faint (bright meteors are the exception), typically white with some blue members, and occasionally leaving trains.

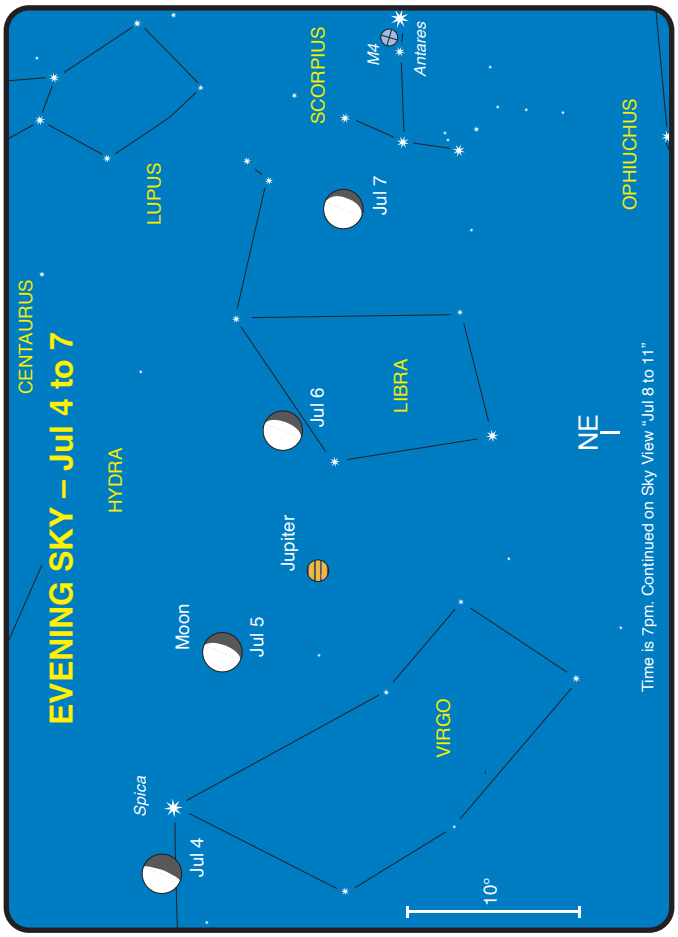
The **alpha-Capricornids** are noted for their bright, slow meteors with long paths and frequent fireballs. The shower is visible late evening until dawn, from 3rd July through to 15th August. Maximum activity occurs this month on the 30th, when a zenith hourly rate of 4 can be expected. Low hourly rates over the period are generally made up by the spectacular nature of the alpha-Capricornids.

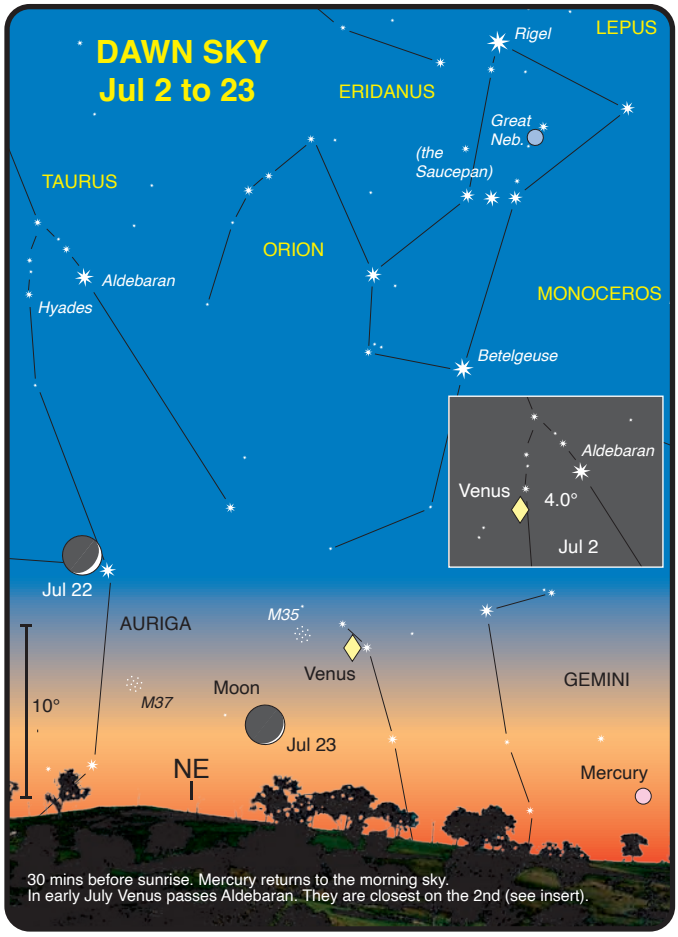
DIARY

2nd	6am	(4am WST) Moon at apogee
2nd	6am	(4am WST) m.p. 2 Pallas at opposition
2nd		Venus 1°S of m.p. 20 Massalia
3rd	6am	(4am WST) Venus 4°N of Aldebaran
4th	2:37am	(12:37am WST) First Quarter
4th	9am	(7am WST) Earth at aphelion
4th		Mercury at aphelion
4th	Noon	(10am WST) Mercury stationary
5th	3am	(1am WST) Spica 0.1°N of Moon Occn.
5th	pm	m.p. 29 Amphitrite 0.3°N of M55 (GC) in Sagittarius
6th	3am	(1am WST) m.p. 7 Iris 0.2°NW of star Eta Piscium
6th	Noon	(10am WST) Jupiter 5°N of Moon
7th	5am	(3am WST) Jupiter stationary
8th	6pm	(4pm WST) Antares 0.2°N of Moon Occn.
8th	pm	m.p. 1 Ceres 0.3°E of m.p. 349 Dembowska
9th	3am	(1am WST) m.p. 7 Iris 0.3°N of M74 (SG) in Pisces
11th	1:02pm	(11:02am WST) Full Moon
11th	9pm	(7pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.3°S of M21 (OC) in Sagittarius
13th	2pm	(Noon WST) Neptune 3°N of Moon
14th	4am	(2am WST) Moon at perigee
14th		Venus 0.7°NE of Crab Nebula (M1) in Taurus
14th		Comet 41P/Tuttle-Giacobini-Kresak 0.8°SW of NGC 4442 (LG) in Virgo
15th	9am	(7am WST) Uranus 0.4°N of Moon Occn.
15th		Venus 1.3°N of star Zeta Tauri
15th		Comet 41P/Tuttle-Giacobini-Kresak 0.7°N of M49 (EG) in Virgo
16th		Pluto 0.4°S of star Xi Serpentis
16th	9pm	(7pm WST) Comet 41P/Tuttle-Giacobini-Kresak 0.1°W of NGC 4535 (SG) in Virgo
17th		m.p. 20 Massalia 1.2°S of NGC 1746 (OC) in Taurus
17th		Comet 41P/Tuttle-Giacobini-Kresak 0.8°NE of NGC 4570 (LG) in Virgo
18th	5:13am	(3:13am WST) Last Quarter
18th	5pm	(3pm WST) Mercury in inferior conjunction
20th		Venus 0.7°SE of NGC 2129 (OC) in Gemini
20th		m.p. 18 Melpomene 1.0°S of NGC 1807 (OC) in Taurus
20th		m.p. 40 Harmonia 0.2°NE of NGC 4123 (SG) in Virgo
21st		Venus 1.5°S of M35 (OC) in Gemini
21st		m.p. 22 Kalliope 0.4°S of star Epsilon Tauri
22nd		Mars 0.6°N of star Regulus
22nd	4pm	(2pm WST) Mars 0.7°N of Regulus
23rd	10am	(8am WST) Venus 6°S of Moon
23rd	pm	m.p. 6 Hebe 0.4°E of Saturn Neb. (BN) in Aquarius
24th		Venus 0.4°NE of star Mu Geminorum
25th		Mercury at greatest latitude South
25th	2:31pm	(12:31pm WST) New Moon
28th	3am	(1am WST) Mars 1.1°S of Moon Occn.
28th		m.p. 44 Nysa 0.6°S of star Epsilon Tauri
29th	3am	(1am WST) Mercury stationary
29th		m.p. 3 Juno 0.7°NE of NGC star Omicron Leonis
29th		m.p. 9 Metis 0.3°E of NGC 4123 (SG) in Virgo
29th	11pm	(9pm WST) Moon at apogee
30th		m.p. 20 Massalia 1.0°N of Crab Neb. (M1) in Taurus
30th	pm	m.p. 6 Hebe 0.4°SE of M73 (OC) in Aquarius
31st		m.p. 39 Laetitia 0.4°S of star Lambda Tauri
31st		m.p. 39 Laetitia 0.4°N of m.p. 97 Klotho
31st		m.p. 97 Klotho 0.8°S of star Lambda Tauri

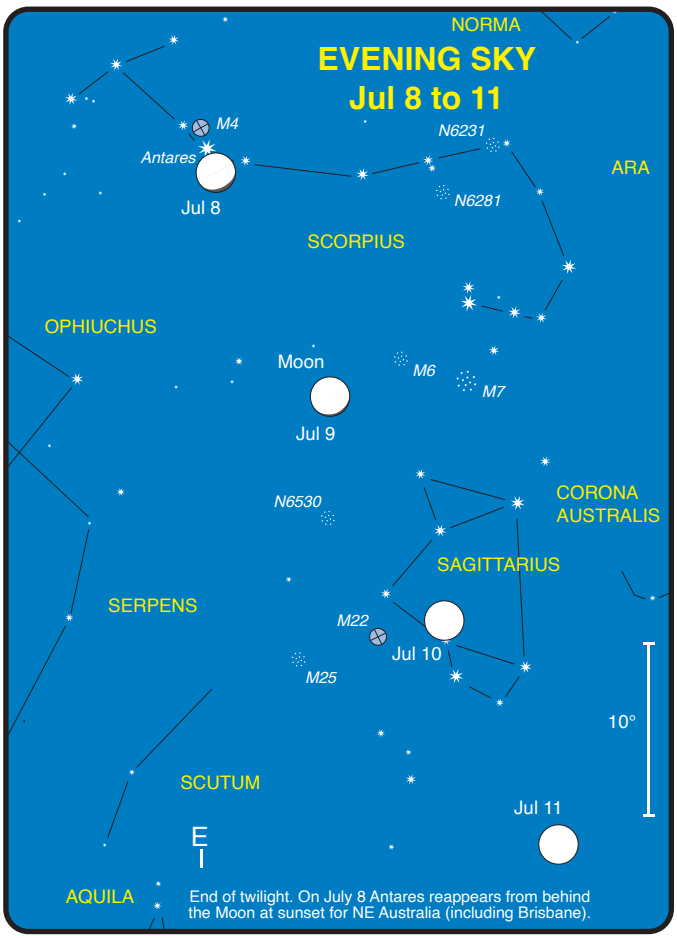


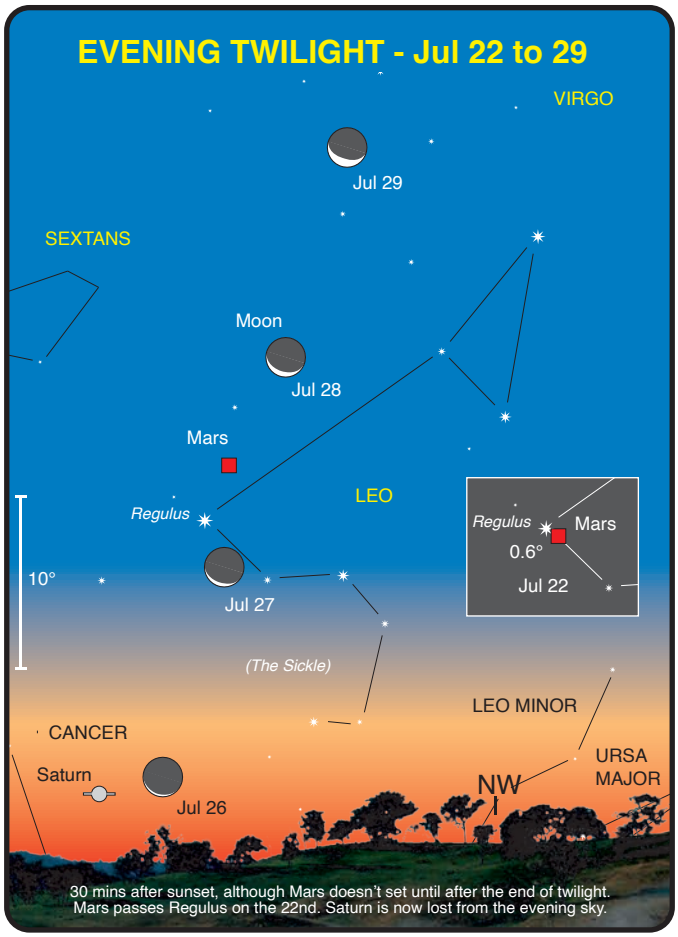
1 hour after sunset. On the 26th and 27th Mercury, Saturn and Mars form a straight line.





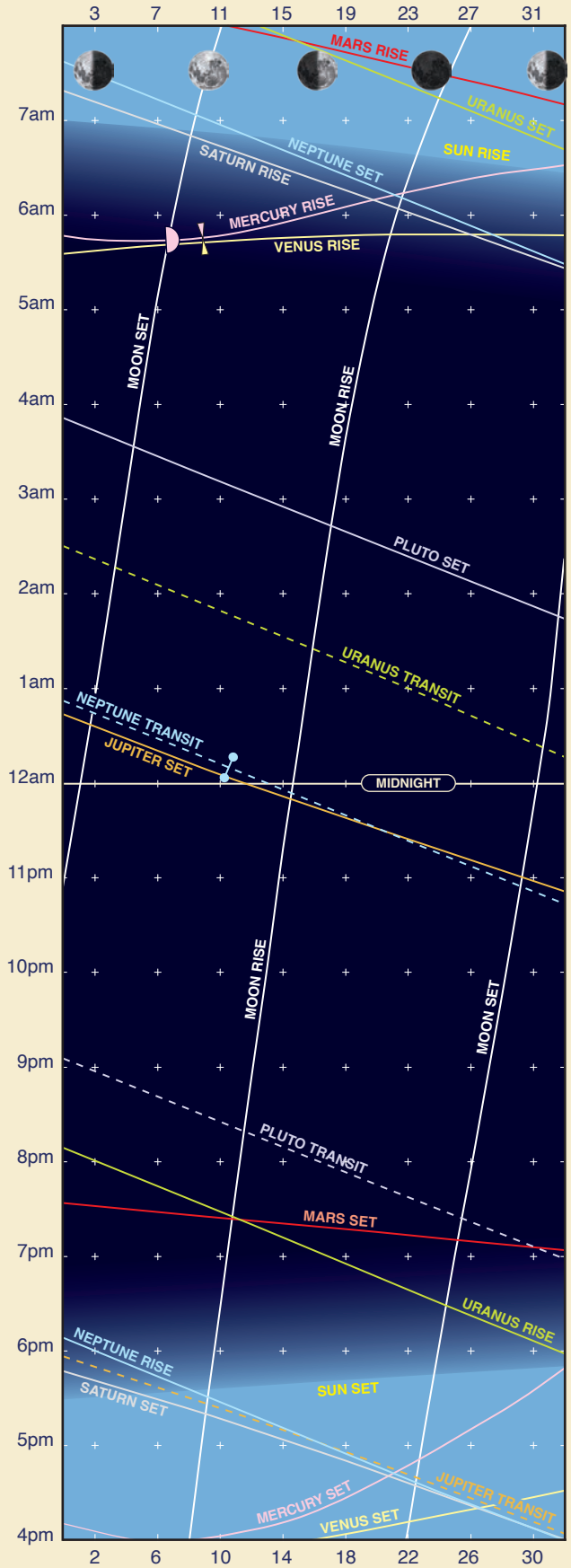
Approximate local standard time.





AUGUST

RISE/SET CHART



Approximate local standard time.

HIGHLIGHTS

- Mercury, Saturn and Venus in close conjunctions.
- Spica very close to Moon.
- Neptune at opposition.
- Minor planet 44 Nysa crosses cluster NGC 1647.

THE MOON

1st Occultation of Spica by the Moon, not visible from Australia.

2nd First Quarter.

5th Occultation of Antares by the Moon. In Australia only WA sees the event. Perth sees a disappearance at 2:34am, but the Moon sets before Antares reappears.

9th Full Moon.

11th Moon at perigee (closest to Earth – 359,749 km distant, angular size 33.6').

11th Occultation of Uranus by the Moon, not visible from Australia.

16th Last Quarter.

24th New Moon.

25th Occultation of Mars by the Moon, not visible from Australia.

26th Moon at apogee (furthest from Earth – 406,269 km distant, angular size 29.7').

28th Occultation of Spica by the 4-day old crescent Moon, visible from far south of the North Island, and all of the South Island of New Zealand. From Australia, Hobart is the only capital city to witness the occultation: Spica disappears behind the lunar limb at 6:59pm and reappears at 7:14pm. From the following places Spica appears just north of the lunar cusp (see Sky View), listed after each city is the distance from the lunar limb in arc minutes and approximate local time: Adelaide 0.6' 6:35pm, Brisbane 0.15' 7:30pm, Canberra 0.7' 7:20pm, Melbourne 0.4' 7:10pm, and Sydney 0.8' 7:20pm. From Perth and Darwin the close approach occurs in the daytime.

APPEARANCE of the PLANETS

MERCURY

7th Aug
Greatest elongation west
dia 7.6"
mag 0.1

15th Aug
dia 6.1"
mag -0.9

25th Aug
dia 5.2"
mag -1.5

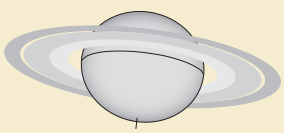
VENUS

15th Aug
dia 10.5"
mag -4.0

MARS

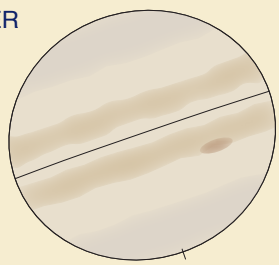
15th Aug
dia 3.7"
mag 1.8

SATURN



15th Aug
dia 16.4"
mag 0.4

JUPITER



15th Aug
dia 35.8"
mag -2.0

URANUS

15th Aug
dia 3.7"
mag 5.7

NEPTUNE

11th Aug
Opposition
dia 2.3"
mag 7.8

PLUTO

15th Aug
dia 0.11"
mag 13.9

THE PLANETS

MERCURY is in the dawn sky. It is at its greatest elongation west of the Sun (19°) on the 7th. This is not a particularly favourable elongation and the planet moves back toward the Sun at month end. Mercury and Venus begin the month 7° apart in Gemini, gradually moving together until they are 2.4° apart from the 9th to 13th (see Sky View). Mercury then slips away toward the Sun, and on the 21st will be located 0.1° from Saturn just before sunrise (close to the Sun and difficult to observe, see Sky View).

VENUS is in the dawn sky. It has a close encounter with Mercury (see Mercury above and Sky View). Saturn rises up to greet Venus throughout August and on the 27th the two planets will be just 0.1° apart; a splendid sight low in the dawn sky, just half an hour before sunrise.

MARS, low in the western evening sky in Leo, sets around 7:30pm. On the 25th, the very slender crescent of the 1-day old Moon appears around 3° below Mars (see Sky View).

JUPITER, in Libra for the entire month, sets around midnight. On the 2nd, the First Quarter Moon appears 4° from the planet (see Sky View). Again at the end of the month, the Moon appears near Jupiter on two consecutive evenings. On the 29th, the 5-day old Moon is 8° away, and on the following evening 7° (see Sky View). The evening of the 28th is busy for Jovian satellite events, including two moons transiting at once (see pp. 113)

SATURN makes its debut in the eastern dawn sky at the end of the month, joining Mercury and Venus in Cancer. The ringed planet has close

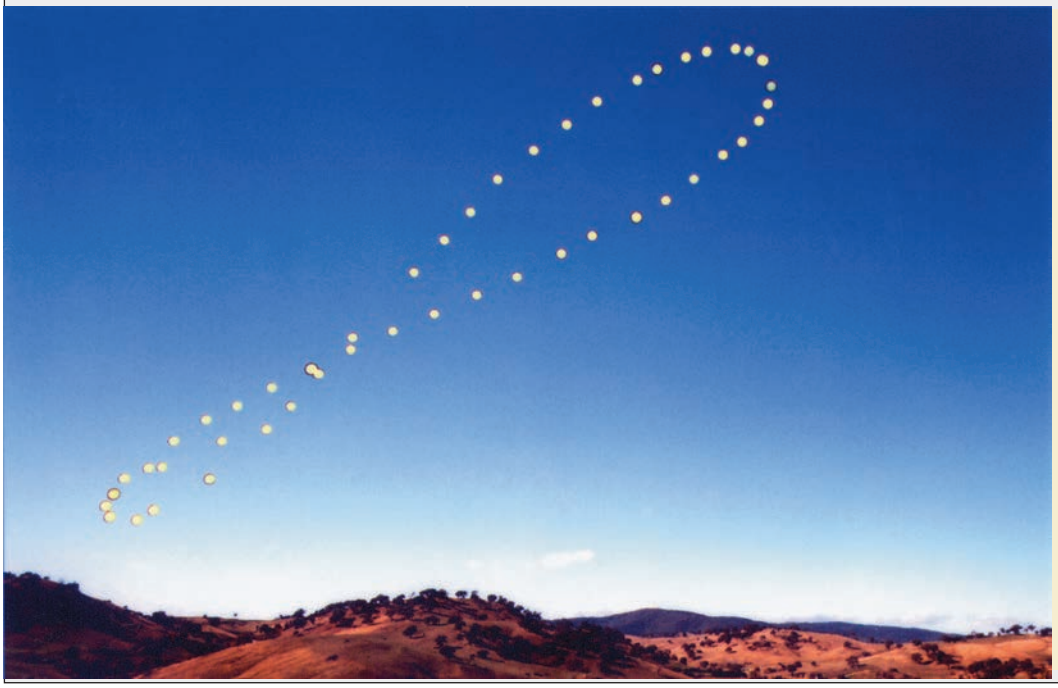
A SOUTHERN ANALEMMA

Someone who has an old globe of the world or is familiar with sundials might recognize this figure eight sign made by the Sun. This curious shape, called the analemma, is generated by photographing the Sun at the same time of the day over a period of a year. Most, like this one, have images taken roughly once a week. It doesn't matter what time of the day it is taken as long as you ensure the Sun is always above the horizon and inside the frame of the camera. During the day the analemma will slowly rotate in the sky until, if you took it at midday, it would be pointing straight up, with the small loop below the larger. This exercise uses very basic equipment, but requires you to dedicate a camera to this one image for a whole year, not to mention having it securely mounted in the same location for this period.

Why this shape? There are two aspects that need explaining. Firstly, the cause of the height of the '8' and, secondly, why are there loops? The height just represents the seasonal change in the declination of the Sun. This is caused by the Earth's axis being tilted by 23.5° from the plane of its orbit around the Sun (the ecliptic). At the extremes of this north-south movement we have the solstices. The Summer Solstice occurs on December 22 in the Southern Hemisphere and this is the right hand end of this double loop. This is when the Sun is furthest south and the time of the year where the Southern Hemisphere is most tilted towards the Sun. In fact the Sun is directly overhead on this day on the Tropic of Capricorn which is at latitude 23.5° S, or about the level of Longreach or Rockhampton. The left hand end of the analemma is the Winter Solstice, which happens on June 22. This is when the Sun is lowest in our skies and the Southern Hemisphere is tilted away from the Sun.

The reason for the loops is connected to the Earth's orbit around the Sun. If the orbit was perfectly circular, at the time of local noon the Sun would always be due north (agreeing with our clock) and our midday analemma would be a vertical straight line; effectively the Earth would be travelling at a constant speed throughout the year. In reality there is no such thing as a circular orbit, the Earth moves in an ellipse. In January the Earth is travelling fastest, being near its perihelion or closest passage to the Sun. At this time, when the Earth has completed one mean solar day, it has travelled further in this 24 hour period compared to the circular (average speed) orbit, and effectively the Sun starts to lag, shifting a little to the east. This is only a matter of a few seconds a day difference, but this effect accumulates until a number of minutes are reached. However, being an ellipse, the speed of the Earth will slow as it moves away from perihelion (its slowest will be during aphelion in July). Once its speed drops below the average for the Earth, the solar drift reverses direction. The difference between the mean time (call it noon if you like) and the Sun's offset, measured in minutes/seconds, is called the Equation of Time.

This image was taken from Victoria and is likely the first time the analemma has been photographed from the Southern Hemisphere. Dennis di Cicco in the March 2000 edition of *Sky & Telescope* wrote an article entitled 'Photographing the Analemma'. In his concluding paragraph he discusses what other opportunities exist for imaging the analemma, including, "And, of course, there would be a shot from any place in the Southern Hemisphere, where the analemma's small loop appears nearer the horizon the way the larger loop does as seen from northern climates." Well Dennis, here it is!



Robert Price from Bethanga, Victoria, took this photograph. He is a long-term contributor of images to our yearbooks, not to mention a long-term amateur when you consider his image of Comet Bennett (see p. 35) was taken in March 1970. His analemma consists of 48 individual images of the Sun taken at approximately one-week intervals (at 8:18am) over a period of one year (2004–05) using a single 35mm film frame. The aperture was f8 and the exposure 1/125sec using a Nikon SLR with 28mm lens and ISO 100 Fuji print film through a Baader solar filter. The background was taken on a separate frame using the same exposure without the filter. This was then combined with the Sun images using Photoshop.

approaches with the two inner planets this month; the first with Mercury is too close to the Sun for observation, but the Venus encounter will be visible in the dawn sky (see Venus).

URANUS rises around 7pm, the planet coming to opposition early in September, is at its brightest for the next two months. Although this is only marginal, i.e., 5.7 magnitude versus 5.9 near conjunction, this might be just the edge needed to see the planet with the naked-eye. In theory, under dark moonless nights 6th magnitude should be possible, but we don't always have ideal observing conditions. In general, if you can see the fainter stars in the All Sky Maps, Uranus is probably worthwhile going after.

NEPTUNE is at opposition on the 11th and is visible the entire night. A special treat for any Neptunian's that may be looking our way on this day, they will witness a transit of the Earth across the face of the Sun. This rare series of transits began in 2001, and ends with this year's opposition.

PLUTO, now two months past opposition, transits the meridian around 8pm.

DIARY

1st		m.p. 22 Kalliope 0.7°N of NGC 1647 (OC) in Taurus
1st	11am	(9am WST) Spica 0.4°N of Moon; Occn.
2nd	6:46pm	(4:46pm WST) First Quarter
2nd	10pm	(8pm WST) Jupiter 5°N of Moon
3rd		Venus at ascending node
5th	4am	(2am WST) Antares 0.4°N of Moon; Occn.
6th		m.p. 44 Nysa 0.04°NW of NGC 1647 (OC) in Taurus
6th	8pm	(6pm WST) m.p. 40 Harmonia 0.1°S of NGC 4517 (SG) in Virgo
6th	10pm	(8pm WST) Mercury 9°S of Pollux
6th	pm	m.p. 10 Hygiea 0.3°S of star Pi Sagittarii
7th		Venus 0.3°NW of NGC 2420 (OC) in Gemini
7th	11am	(9am WST) Mercury greatest elongation West (19°)
7th	10pm	(8pm WST) Saturn in conjunction with Sun
8th	6pm	(4pm WST) Venus 7°S of Pollux
9th	8:54pm	(6:54pm WST) Full Moon
9th	10pm	(8pm WST) Neptune 3°N of Moon
9th	pm	m.p. 15 Eunomia 0.9°N of star Beta Capricorni
11th	4am	(2am WST) Moon at perigee
11th	3pm	(1pm WST) Neptune at opposition
11th	3pm	(1pm WST) Transit of Earth & Moon across the Sun as seen from Neptune
11th	4pm	(2pm WST) Uranus 0.3°N of Moon Occn.
12th		m.p. 20 Massalia 0.3°SE of NGC 2129 (OC) in Gemini
12th		m.p. 40 Harmonia 0.4°N of star Gamma Virginis
13th	1am	(11pm WST, prev day) m.p. 1 Ceres at opposition
13th		Mercury at ascending node
13th	pm	m.p. 6 Hebe 1.4°SE of M72 (GC) in Aquarius
14th		m.p. 20 Massalia 1.0°S of IC 2157 (OC) in Gemini
15th	8pm	(6pm WST) m.p. 9 Metis 0.2°S of NGC 4517 (SG) in Virgo
16th		m.p. 20 Massalia 1.3°S of M35 (OC) in Gemini
16th	11:51am	(9:51am WST) Last Quarter
17th		m.p. 40 Harmonia 1.0°SW of NGC 4753 (SG) in Virgo
17th		Mercury at perihelion
19th		Venus 0.9°S of Beehive Cluster (OC) in Cancer
19th	pm	m.p. 29 Amphitrite 0.5°SW of star Zeta Sagittarii
21st	9am	(7am WST) Mercury 0.5°N of Saturn
21st		m.p. 9 Metis 0.3°N of star Gamma Virginis
22nd		m.p. 20 Massalia 0.4°N of star Mu Geminorum
22nd	1pm	(11am WST) Venus 3°S of Moon
23rd	3am	(1am WST) Comet 4P/Faye 0.2°S of star Eta Piscium
24th	5:10am	(3:10am WST) New Moon
24th		m.p. 97 Klotho 0.6°N of NGC 1662 (OC) in Orion
24th	8pm	(6pm WST) m.p. 2 Pallas stationary
25th	pm	m.p. 704 Interamnia 0.5°S of star Epsilon Pegasi
25th	Midnight	(10pm WST) Mars 0.6°N of Moon Occn.
26th	11am	(9am WST) Moon at apogee
26th	pm	Comet 4P/Faye 0.5°S of M74 (SG) in Pisces
27th	9am	(7am WST) Venus 0.07°N of Saturn
28th		Mercury at greatest latitude North
28th	6pm	(4pm WST) Spica 0.5°N of Moon Occn.
29th		m.p. 29 Amphitrite 1.0°S of M54 (GC) in Sagittarius
30th	11am	(9am WST) Jupiter 5°N of Moon

MINOR PLANETS at opposition this month include: 6 Hebe on the 5th at magnitude 7.8 in Aquarius, 1 Ceres on the 12th at magnitude 7.6 in Piscis Austrinus, 349 Dembowska on the 12th at magnitude 9.7 in Piscis Austrinus and 704 Interamnia on the 25th at magnitude 10.0 in Pegasus. On the morning of the 6th, 44 Nysa can be seen crossing the open star cluster NGC 1647. This new 11th magnitude 'star' may be hard to find, but images taken 30 minutes apart or sketches over an hour or two may help.

COMETS

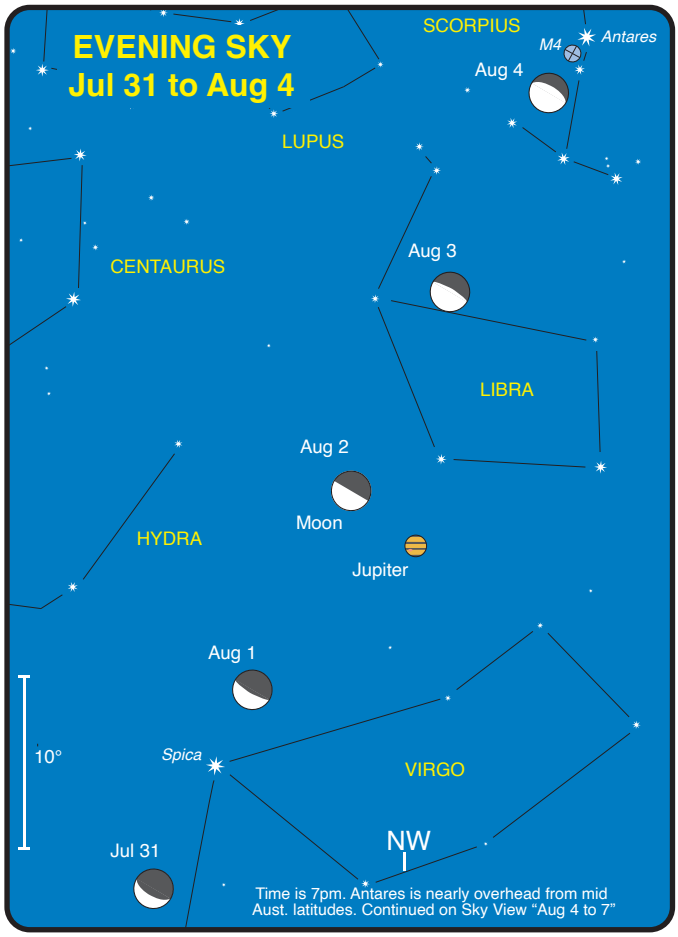
Comet C/2004 B1 (LINEAR) arcs in a southward direction through Corona Borealis during August. Found several degrees west of Beta Coronae Borealis, the comet is setting late in the evening and is best observed at the end of twilight. By month's end, LINEAR is expected to have faded to 13th magnitude.

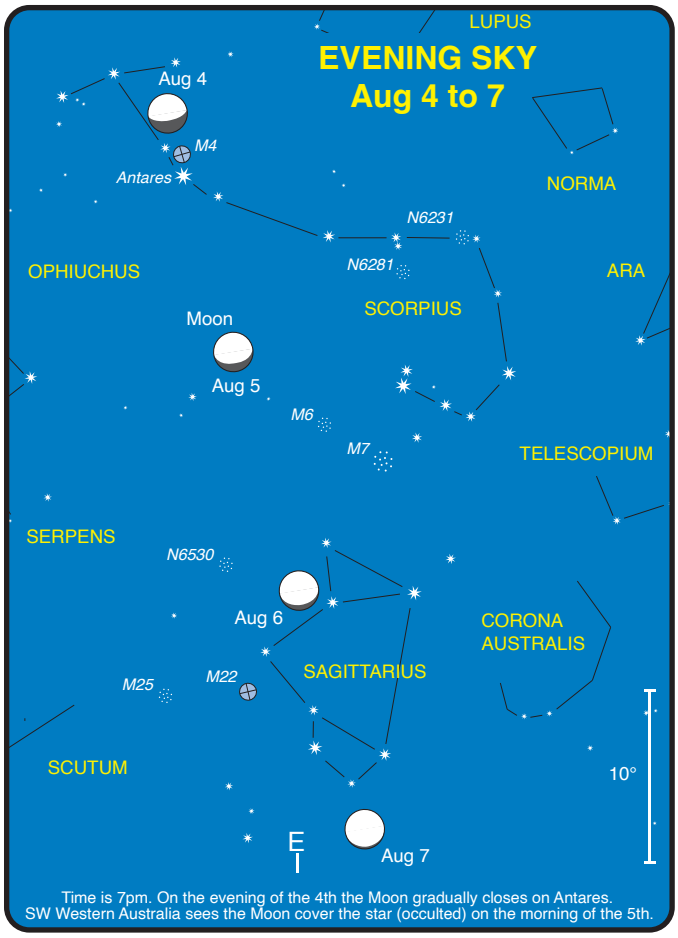
Comet 4P/Faye moves eastward through Pisces in August and should brighten from 13th to 12th magnitude. Rising late in the evening, and thus best observed after midnight, Faye passes south of Eta Piscis on August 23rd. A few days later, on August 26th, the comet is within a degree of the galaxy M74.

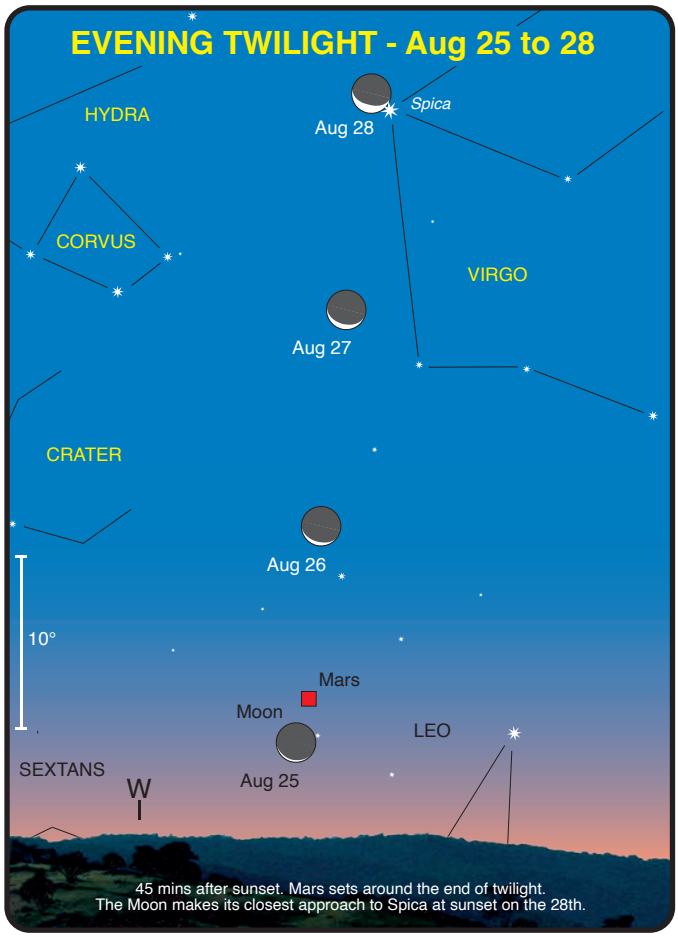
Comet 71P/Clark is moving northeast through Sagittarius this month. Fading from 11th to 13th magnitude, the comet is visible until just before dawn each night.

Comet 73P/Schwassmann-Wachmann 3-B should fade from 11th to 13th magnitude this month. Located in Cetus, the comet rises late in the evening.

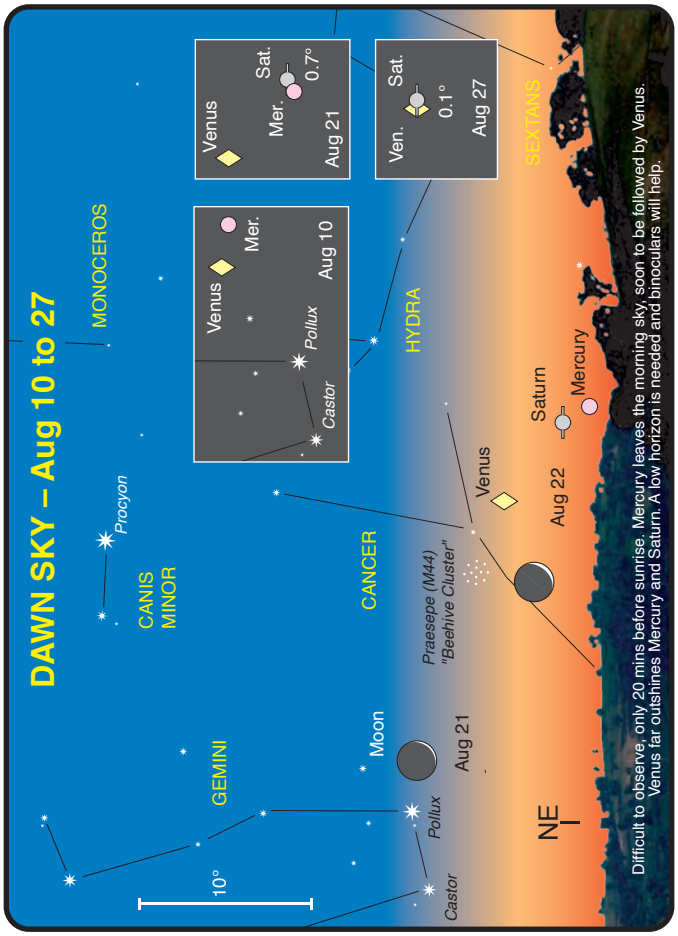
Comet 73P/Schwassmann-Wachmann 3-C is rising late in the evening during August. Moving southwest through Cetus, the comet might fade from 8th to 10th magnitude by month end (see finder p. 39). The comet stays within a degree of the B component during the month.

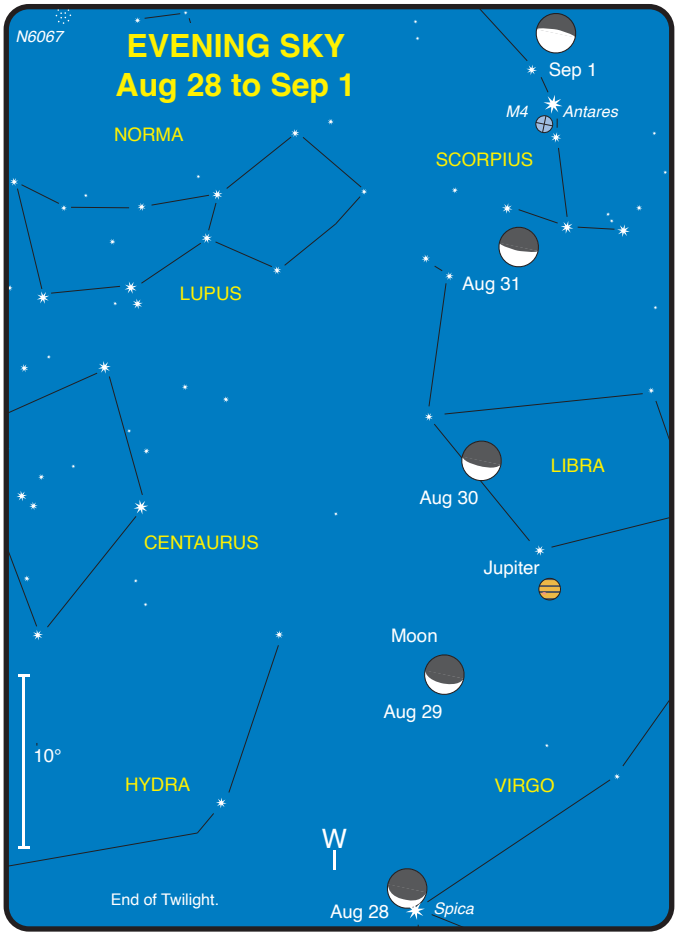






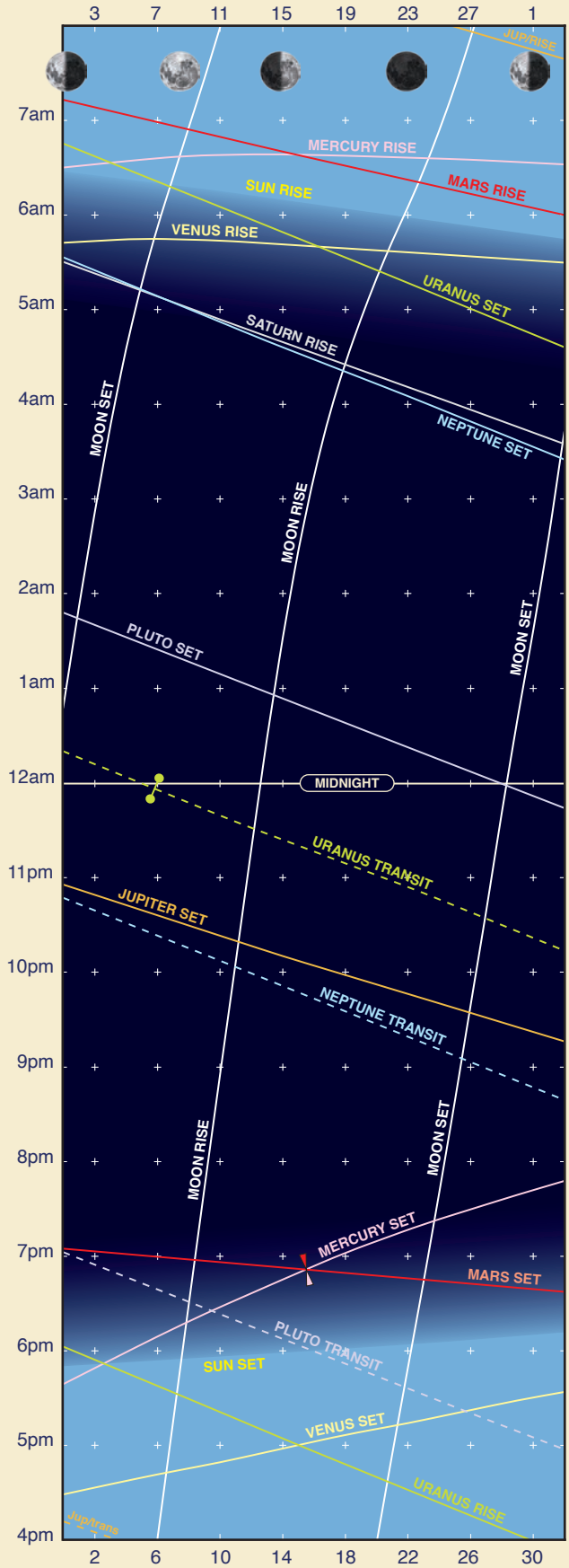
Approximate local standard time.





SEPTEMBER

RISE/SET CHART



Approximate local standard time.

HIGHLIGHTS

- Occultation of Uranus by the Moon.
- Partial lunar eclipse.
- Antares close to Moon.
- Mercury close to Mars.
- Mercury close to Spica.

THE MOON

1st First Quarter.

1st Occultation of Antares by the Moon, not visible — daytime event.

8th Occultation of Uranus by the Moon. Visible across Australia, except the far northwest. See Part II for occultation times, from Darwin at 12:35am Uranus misses the lunar limb by just 1 arc minute. From the eastern states the occultation occurs on the morning of the 8th, from Perth the occultation occurs on the evening of the 7th, and from Adelaide the occultation begins on the 7th and ends on the 8th.

8th Full Moon. Partial lunar eclipse, visible across Australia. See Part II for full details.

8th Moon at perigee (closest to Earth – 357,175 km distant, angular size 33.0').

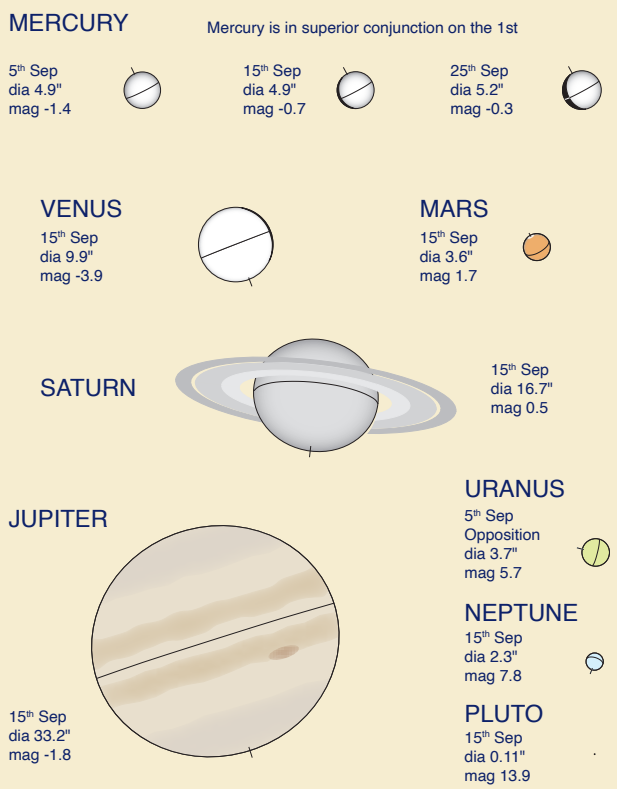
14th Last Quarter.

22nd Moon at apogee (furthest from Earth – 406,500 km distant, angular size 29.6').

22nd New Moon. Annular eclipse of the Sun. Not visible from Australia, see Part II for full details.

24th Occultation of Spica by the Moon. Not visible from Australia, Spica however appears a few degrees directly above the slender crescent of the 2-day old Moon in the early western evening sky (see Sky View).

APPEARANCE of the PLANETS



28th Occultation of Antares by the Moon. Not visible from Australia, however Antares appears very close to the cusp of the 5-day old Moon, particularly from the eastern states, in the early evening western sky (see Sky View). The occultation is visible from New Zealand.

30th First Quarter.

THE PLANETS

MERCURY is at superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 1st; the planet then rises up into the western evening sky. The period from mid-month and all of next month is the best period for observation of this world in the evening sky. Mercury gains altitude rapidly and heads straight for Mars, and on the 15th and 16th the pair will be just 0.5° apart (see Sky View). Leaving Mars behind, the planet continues its upward climb and will be 1.3° north of the 1st magnitude star Spica (Alpha Virginis) on the 28th. On the 24th, Mercury will be just 3° from the slender crescent of the 2-day old Moon (see Sky View).

VENUS in the dawn sky becomes too close to the Sun for observation. The planet will be in superior conjunction later next month, and will return to the evening sky in late November.

The **EARTH** is at its vernal (spring) equinox on the 23rd. The Sun rises and sets due east and west and day and night are equal.

MARS bids farewell this month as it sinks into the western twilight. On the 15th and 16th, the Red Planet will be close to Mercury (see Mercury, above, and Sky View). Interestingly, the planet's angular size this month is a little smaller than distant Uranus, a reminder as to why we look forward to the biannual oppositions. Mars will be in conjunction with the Sun next month and will return to the morning skies in late November.

JUPITER appears high in the early western evening sky, setting around 10pm. On the 26th, the 3-day old crescent Moon appears 6° south of the planet (see Sky View). The evenings of the 6th and 13th are busy for Jovian satellite events (see pp. 113). The later evening events are more suited for Western Australia.

SATURN moves from Cancer into Leo at the beginning of September. The planet will meander within the boundaries of this constellation for the next three years, before moving into Virgo in September 2009. On the 19th, the 26-day old waning crescent Moon will be located 5° to the north of Saturn (see Sky View).

URANUS is at opposition on the 5th, and is visible the entire night. The planet is occulted by the Full Moon on the 8th, an event visible across Australia except the far northwest of the continent (see Moon above, and Part II for occultation times).

NEPTUNE is well placed for observing in the evening, transiting the meridian around 9:30pm. Neptune spends the month around 1° north

THE REFLEX FINDER

This article is directed more at the novice, as anyone with some level of experience will likely be full of praise for this handy accessory for your telescope. There are a number of reflex-type finders on the market but they all have one basic function and that is to project a luminous image, focused at infinity, on the sky, which is centred on the field of view of your telescope. These straight-through sights do not magnify or invert the sky, like your conventional finders. Some people are so impressed with their 'reflex' it has sometimes been used to replace their more typical finders. More often it is used in conjunction with their normal finder. The most common type is the Telrad but there are probably around ten marketed throughout the world.

Red Dot Finders The projected image can be just a small red point of light and this is sometimes why they are called Red Dot Finders or RDFs. Examples of these include the Orion EZ Finder (see image), TeleVue Quik Point and Vixen Red Dot Finder.

Reticule Finders. The construction is very similar to the RDFs but they project a bull's eye-like set of red concentric circles. Examples of these include the Telrad (see image) and the Rigel QuikFinder. The Telrad's show three circles with diameters of 0.5, 2.0 and 4.0 degrees.

Although there are some differences, like the Red Dot versus the Reticule, there are many common design features, some include:

- Variable brightness control on the 'target'. Some can even pulse or blink the light.
- They normally come with a separate base so you don't have to store the finder attached to your telescope. This is also handy if you want to use the unit on more than one telescope. All you need is to buy a second base.
- They come with a system to easily align the target with the field of view of your scope.
- Some, like the Telrad, use double-sided adhesive tape to secure the base to the telescope – avoiding having to drill holes. This might sound crude but with these modern tapes make sure you are happy with the placement, for you might have trouble moving it afterwards.
- Their cost in Australia is normally around $70 to $100.

Don't rely on this list alone when considering a purchase. Ensure the specific model meets your requirements. Here are a few tips on using these finders:

- If you don't observe under reasonably dark skies these finders will have limited use. It would be a bit like using a street directory which only has the main roads marked on it. You might have no problem finding a suburb (or constellation in this case) but then finding a minor street is another matter.
- They can be prone to dewing, especially the Telrads. Although there are commercial dew shields available for the Telrad, a cardboard or plastic sheet can be easily cut to shape, bent around the exposed glass flat and attached using Velcro tape. We're sure this approach can be adapted to any model if you strike this problem.
- When positioning the unit on your telescope:
  - Think about where your nose and mouth is when you are observing through the telescope. You don't want your breath continually fogging your finder. Hence on a Dobsonian, avoid placing it immediately under the rack and pinion.
  - Although these units are normally light weight, when using it on a Dobsonian ensure the tube is still in balance before permanently mounting the unit. It is a good idea to have one of your heaviest eyepieces in as well before performing this check.
- When using them keep both eyes open. It is a more natural feeling and having your second eye looking at the same piece of sky helps you to see fainter stars. Of course allow some time to be dark-adapted.

In Australia you are unlikely to find reflex finders in your local camera or department store. They can be purchased from more specialised telescope dealers and links to many of their websites can be found on the Quasar Publishing site.

www.quasarastronomy.com.au

Right, Orion EZ Finder; below, Telrad

to northwest of 4th magnitude star Iota Capricorni. Neptune moved into Capricornus in November 1998 and will continue its crawl through the constellation until March 2010, when it moves into Aquarius.

PLUTO transits the meridian at sunset, setting a little after midnight. In the last week of September Pluto moves back into Ophiuchus, after being in Serpens Cauda since September 2004.

MINOR PLANETS at opposition this month include: 14 Irene on the 5th at magnitude 10.6 in Aquarius, 68 Leto on the 16th at magnitude 9.6 in Aquarius and 25 Phocaea on the 25th at magnitude 10.0 in Pegasus.

COMETS

Comet 4P/Faye moves southeast through Pisces and Aries this month. Rising mid-evening, and observable for the rest of the night, comet Faye could brighten from 11th to 10th magnitude by the end of September.

Comet 73P/Schwassmann-Wachmann 3-C is moving west through Cetus this month. Rising early in the evening, the comet may fade from 10th to 12th magnitude. It spends the month less than a degree northeast of its much fainter 'B' companion.

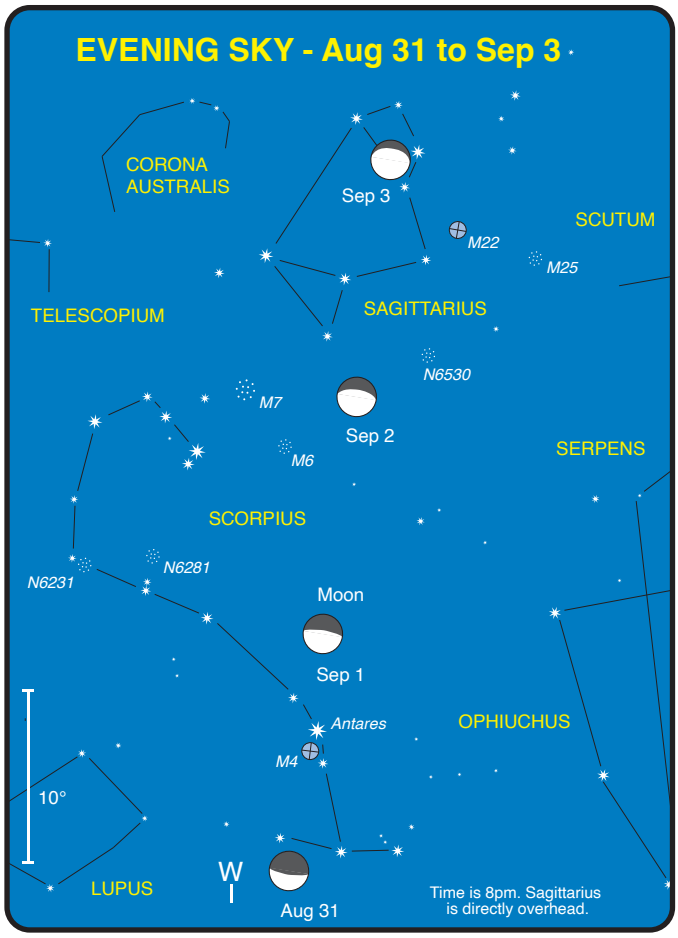
METEOR SHOWERS

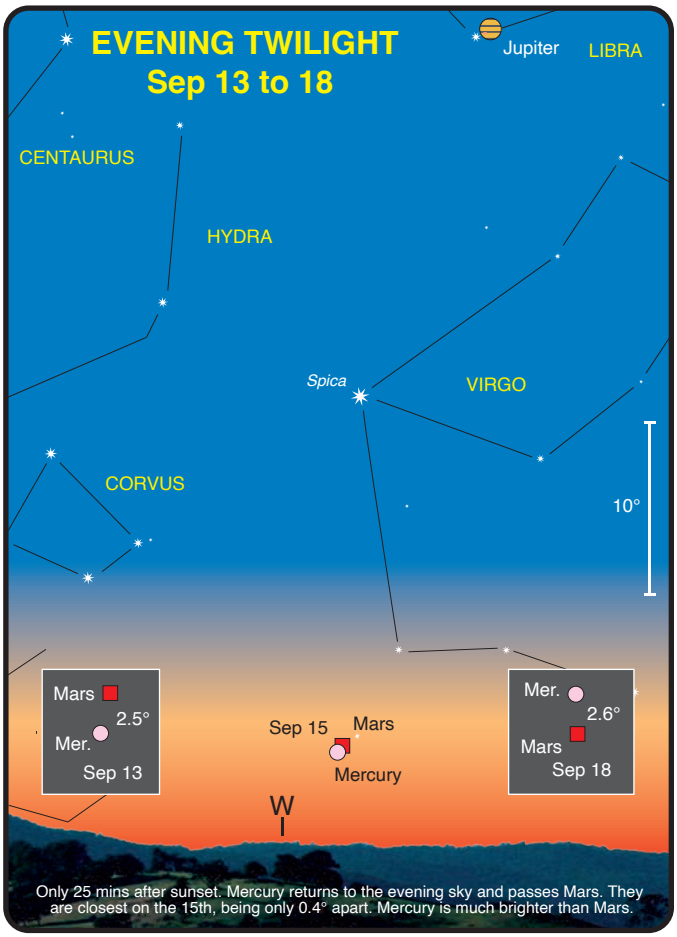
The **Piscids** are a minor shower that little is known about. They are active all month, maximum on the 19th; expect a zenith hourly rate of 3.

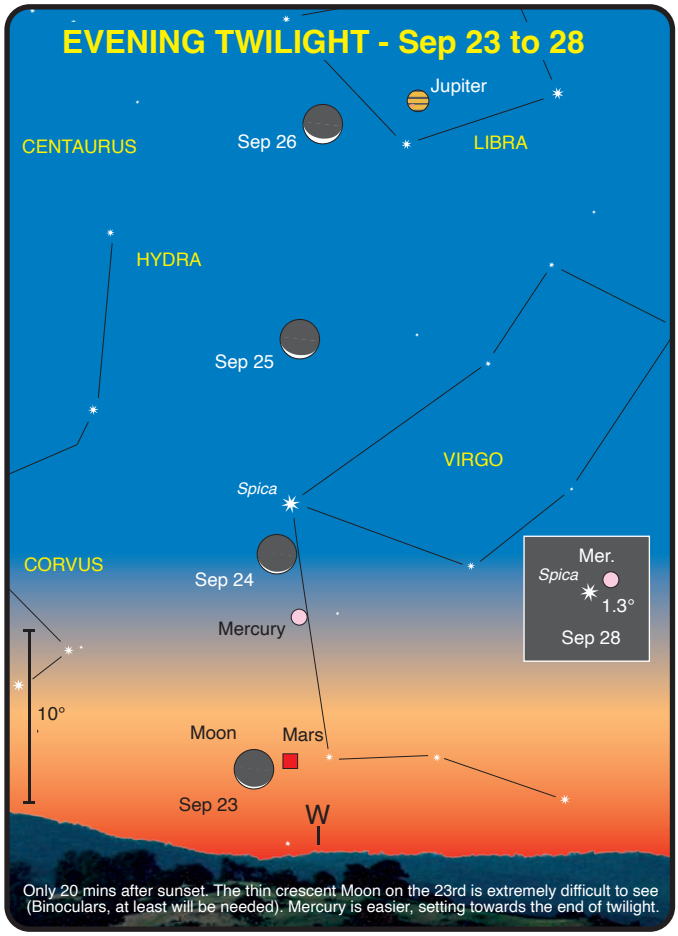
DIARY

1st	8:57am	(6:57am WST) First Quarter
1st	Noon	(10am WST) Antares 0.5°N of Moon Occn.
1st	3pm	(1pm WST) Mercury in superior conjunction
2nd	4pm	(2pm WST) m.p. 3 Juno in conjunction with Sun
4th		m.p. 22 Kalliope 0.3°N of Crab Neb. (M1) in Taurus
4th		m.p. 44 Nysa 1.2°S of star Zeta Tauri
5th	9pm	(7pm WST) Pluto stationary
5th	9pm	(7pm WST) Uranus at opposition
6th	8am	(6am WST) Neptune 3°N of Moon
6th	9am	(7am WST) Venus 0.8°N of Regulus
6th		Venus at perihelion
7th		m.p. 39 Laetitia 0.5°N of NGC 1662 (OC) in Orion
8th	1am	(11pm WST, prev day) Uranus 0.4°N of Moon Occn.
8th	4:42am	(2:42am WST) Full Moon; Eclipse
8th	1pm	(11am WST) Moon at perigee
11th	11am	(9am WST) m.p. 4 Vesta in conjunction with Sun
13th		Jupiter 0.5°NE of star Alpha Librae
14th	9:15pm	(7:15pm WST) Last Quarter
16th	7am	(5am WST) Mercury 0.2°S of Mars
16th		m.p. 18 Melpomene 0.2°W of NGC 2355 (OC) in Gemini
17th		Neptune 1.2°NW of star Iota Capricorni
19th	1pm	(11am WST) Saturn 2°S of Moon
20th		m.p. 63 Ausonia 0.5°N of star Pi Scorpii
20th		m.p. 97 Klotho 0.2°SW of star Lambda Orionis
20th		Mercury at descending node
21st		m.p. 532 Herculina 1.0°N of NGC 6401 (GC) in Ophiuchus
22nd		m.p. 18 Melpomene 0.4°S of NGC 2395 (OC) in Gemini
22nd	3pm	(1pm WST) Moon at apogee
22nd	pm	m.p. 2 Pallas 0.8°NE of star 72 Ophiuchi
22nd	9:45pm	(7:45pm WST) New Moon; Eclipse
23rd		m.p. 20 Massalia 0.4°N of Eskimo Neb. (PN) in Gemini
23rd	2pm	(Noon WST) Equinox
24th		m.p. 44 Nysa 0.7°S of NGC 2175 (OC) in Orion
24th	2pm	(Noon WST) Mercury 1.8°N of Moon
24th	pm	m.p. 10 Hygiea 0.2°N of star Pi Sagittarii
24th	Midnight	(10pm WST) Spica 0.5°N of Moon Occn.
26th		m.p. 29 Amphitrite 0.4°SE of star Tau Sagittarii
27th	2am	(Midnight WST, prev day) Jupiter 5°N of Moon
28th	1am	(11pm WST, prev day) Mercury 1.3°N of Spica
28th		Mercury 1.2°NE of star Spica
28th		m.p. 20 Massalia 0.6°S of NGC 2420 (OC) in Gemini
28th		m.p. 22 Kalliope 0.5°N of NGC 2129 (OC) in Gemini
28th		Venus at greatest latitude North
28th	6pm	(4pm WST) Antares 0.5°N of Moon Occn.
29th		m.p. 68 Leto 1.0°S of NGC 7727 (SG) in Aquarius
30th		m.p. 63 Ausonia 0.6°S of star Sigma Scorpii
30th		Mercury at aphelion
30th	9:04pm	(7:04pm WST) First Quarter

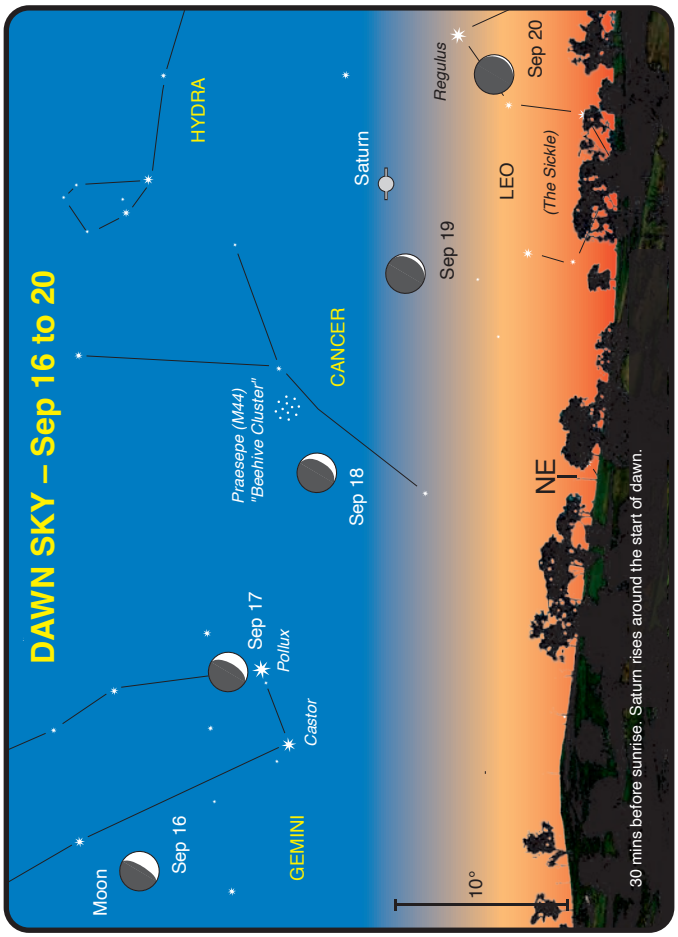
M16 in Serpens (Joe Cauchi) *Although the prime time of the year for viewing the centre of the Milky Way is now slipping below the horizon, it can still be viewed in the early evening in the western sky. M16, or the Eagle Nebula, is approximately 12° north of the teapot of Sagittarius. To put our cover image in perspective the yellow dashed box represents the field in Serpens taken by the Hubble Telescope.*

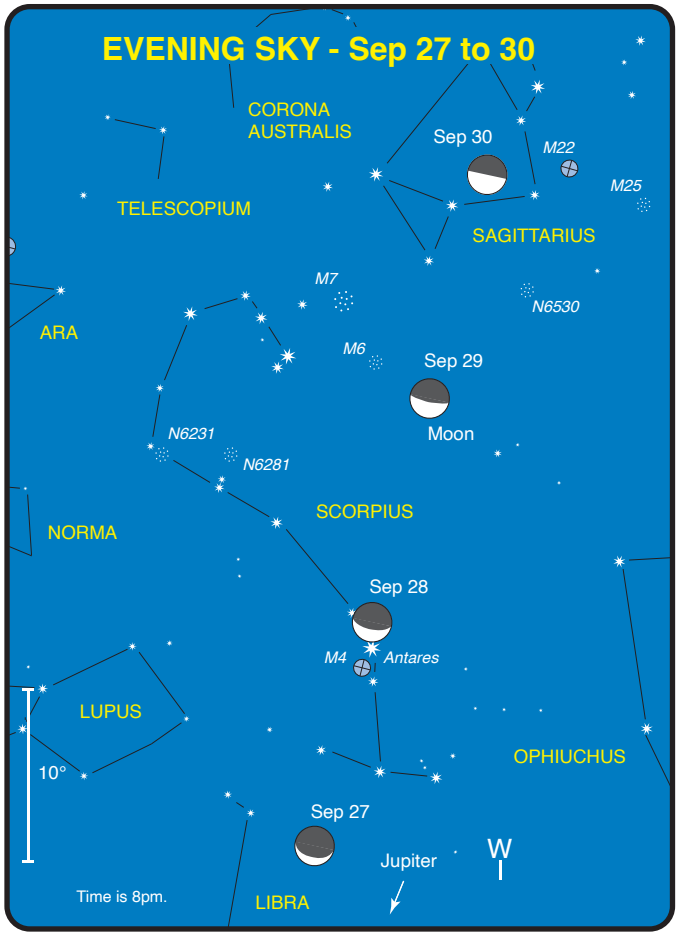






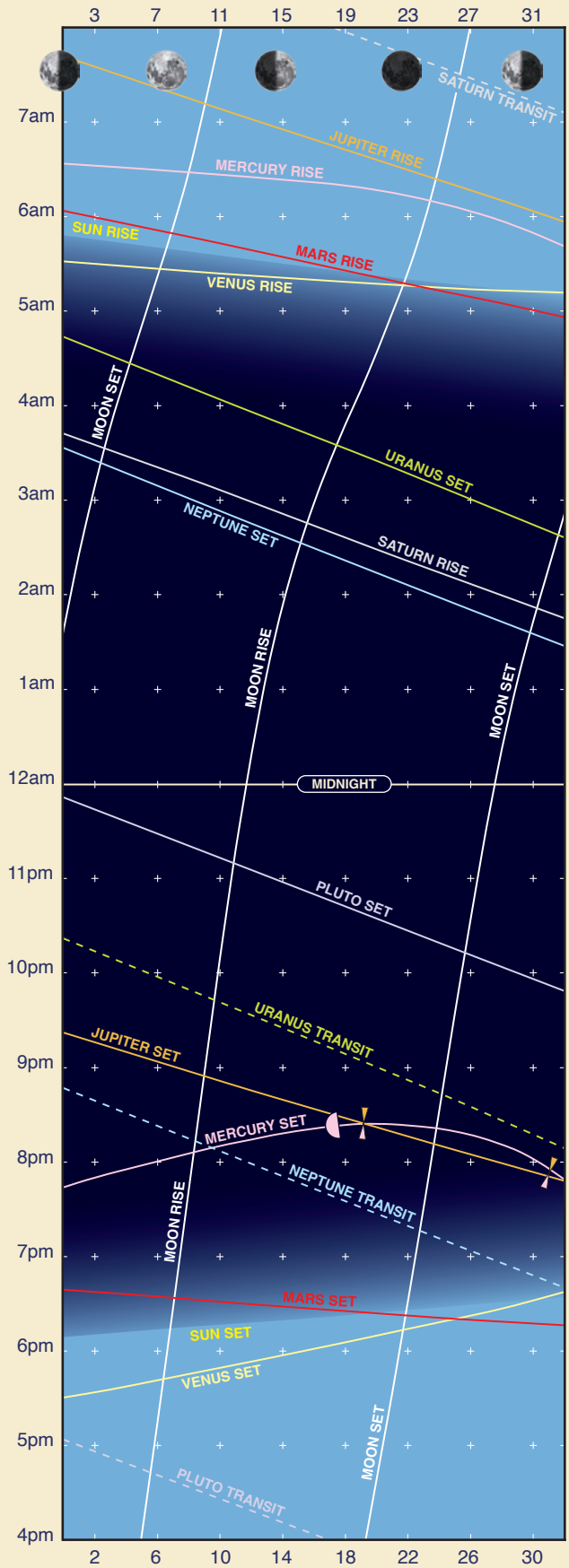
Approximate local standard time.





OCTOBER

RISE/SET CHART



Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Mercury and Jupiter close.
- Mercury at greatest elongation.
- Mercury and Moon close.
- Mercury, Jupiter and crescent Moon close.

THE MOON

5th	Occultation of Uranus by the Moon, not visible from Australia.
6th	Moon at perigee (closest to Earth – 357,410 km distant, angular size 33.9').
7th	Full Moon.
14th	Last Quarter.
19th	Moon at apogee (furthest from Earth – 406,074 km distant, angular size 29.1').
20th	Occultation of minor planet Juno by the Moon, not visible from Australia.
22nd	New Moon.
25th	Occultation of Antares by the Moon, not visible from Australia.
30th	First Quarter.

APPEARANCE of the PLANETS

MERCURY

5th Oct
dia 5.6"
mag -0.1

17th Oct
Greatest elongation east
dia 6.7"
mag 0.0

25th Oct
dia 7.8"
mag 0.2

VENUS

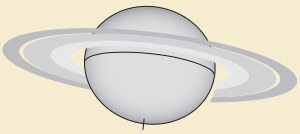
5th Oct
dia 9.8"
mag -3.9

Venus is in superior conjunction on the 28th

MARS

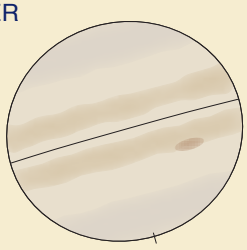
15th Oct
dia 3.6"
mag 1.6

SATURN



15th Oct
dia 17.3"
mag 0.5

JUPITER



15th Oct
dia 31.6"
mag -1.7

URANUS

15th Oct
dia 3.6"
mag 5.8

NEPTUNE

15th Oct
dia 2.3"
mag 7.9

PLUTO

15th Oct
dia 0.10"
mag 14.0

THE PLANETS

MERCURY is in a very favourable position for observation in the western evening sky all month. The planet reaches its greatest elongation east of the Sun (25°) on the 17th, and for most of October sets around two hours after the Sun. The month begins with Mercury some 20° below Jupiter, thereafter the two planets move together and from the 19th they will be within 4° of each other, and closest at 3° on the 31st. On the 24th Mercury will be 1.2° north of the 2-day old slender crescent Moon, with Jupiter 5° north, a pretty sight in the twilight sky (see Sky View).

VENUS is too close to the Sun for observation this month. The planet will be in superior conjunction (Venus and Earth on opposite sides of the Sun) on the 28th, and will return to the evening sky in late November.

ASTERISMS

No matter how experienced you are at looking at the night sky, we all find our way around by looking for familiar star patterns. Some may not be connected to any particular constellation, like the **False Cross**, which borrows bright stars from both Carina and Vela (see All Sky Map No. 1). Such groupings are known as asterisms (we know it sounds more like something you would use to correct the grammar in this sentence). Some of the more distinctive patterns may have names — titles that are quite often more appropriate than the figures they are supposed to represent. For example, it is much easier to think of Sagittarius as **The Teapot**, than as a half-man, half-horse figure using a bow and arrow!

In astronomy, an asterism is a recognised pattern of stars which is neither an official constellation nor a true star cluster; they are considered to be distinct from constellations. An asterism might be part of a constellation, composed of stars from two or more constellations, or a distinctive pattern of stars which are not physically associated and therefore not classified as a cluster. Based on this definition, the popular practice of referring to groupings such as the Pleiades, Southern Pleiades and the Trapezium as asterisms is technically incorrect.

The following are a few examples of obvious naked-eye asterisms not already mentioned; each is wholly contained within a single constellation.

The Scorpion of Scorpius. Probably the most well known constellation to actually look like the object it represents (see Map 6).

Saucepan in Orion. Its base is the three belt stars with the handle being Orion's sword.

The Sickle of Leo. The handle starts at Regulus and follows the line, as shown on Map 5, out to the point at ε Leonis. Although the shape of the lion can be clearly seen in this northern collection, he is upside down for us and the sickle is perhaps more appropriate for the Southern Hemisphere.

The Hyades (Mel 25) in Taurus. This arrowhead shaped asterism, with γ at the tip, is the face of the bull (see Map 3).

The Circlet of Pisces. A circle comprising 6 stars around 4th to 5th magnitude, approximately 7° across (see Maps 8, 9). An easy naked-eye group but needs dark skies to observe.

The following are examples of obvious naked-eye asterisms made up of stars from more than one constellation.

The Southern Cross and Pointers (see Map 1 and image below). The obvious guidepost to the southern skies made up from α and β Centauri and the constellation of Crux.

The Summer Triangle. A very large asterism, some 35° long, is composed of Deneb (α Cygni), Altair (α Aquilae) and Vega (α Lyrae). See Map 9. For Australia this would be better called the Winter Triangle, being well placed in our northern sky around the middle of the night in July.

The Winter Triangle, consists of Betelgeuse (α Orionis), Procyon (α Canis Minoris) and Sirius (α Canis Majoris), see Map 4. For Australia this would be better called the Summer Triangle.

The Great Square of Pegasus. Even this well known shape needs to borrow α Andromedae to complete the square (see Map 9).

Asterisms can be any size, shape or brightness. Here are a few ideal for binoculars but dark skies are recommended.

Collinder 399 in Vulpecula (the Coat hanger cluster or Brocchi's cluster). It is northwest of the arrow shaped constellation of Sagitta (4° from α Sagittae). It consists of ten stars arranged in the shape of a coat hanger. It's about 1.5° long with the star's magnitudes ranging from 5 to 7 (see Map 9).

The Horseshoe in Circinus. This is a group of around a dozen 7th and 8th magnitude stars arranged in a semicircle with a diameter of about 1°. The eastern end star is 6th magnitude ζ Circini. Its centre is 1.5° southeast of α Circini.

These are a few asterisms that are easily visible in the smallest telescope.

M73 in Aquarius. A Y shaped group of 4 stars of magnitudes 10.3, 11.1, 12.4 and 12.8, fitting in a one arc minute circle. This is difficult to find but it might help to go 1.3° due east of M72 (see Map 8).

Another teapot? There is an interesting asterism located northwest of ξ Herculis. This group and ξ fit in a half-degree circle. It consists of nine stars (8 to 10th magn) arranged in the shape of a teapot similar to Sagittarius (see Maps 7 and 9).

Dolphin's Diamonds in Delphinus. The Diamonds consist of around twelve stars (ranging in magnitude from 9 to 11), in an arrangement approximately 0.5° in diameter. It is close to the border with Pegasus, 1.3° east of the globular cluster NGC 7006, or 5° east of the 4th magnitude star γ Delphini (see Map 9).

The Stargate in Corvus. A striking group of 5 stars dominated by a pair of 6.5 magnitude stars separated by 1 arc minute. It is 1° west southwest of M104 in Virgo (see Map 6).

The Jaws in Virgo. A group of 9th magnitude stars shaped like a miniature Sagitta. This is close to the Stargate (see above), being approximately 0.5° west of M104.

It can be fun scanning the heavens looking for interesting asterisms. Low-power binoculars are ideal for such work. If you find any, feel free to name it (after all there is nothing official here) and drop us a note. If we get a good response we'll post them on our website or in a future

Southern Cross and Pointers

Probably the most recognisable asterism associated with the Southern Hemisphere. As a testament to this, we only have to look at the Australian or New Zealand flag. They are circumpolar from many southern population centres. Taken on Kodak T Max (400 ASA) for 5 minutes (piggy-backed on an equatorially tracking telescope) through a 35mm camera (55mm lens).

MARS is also is too close to the Sun for observation. The planet is in conjunction with the Sun on the 23rd, and will return to the morning sky in late November.

JUPITER sets in the western evening sky around 8:30pm. Jupiter and Mercury become close companions in the later part of October (see Mercury). A pretty picture will be seen on the 24th with the 2-day old crescent Moon 5° south of Jupiter, with Mercury between the two (just 1.2° from the lunar cusp, see Sky View).

SATURN, in Leo, rises around 3am in the eastern morning sky. On the 17th, the planet will be just 3° above the waning crescent 25-day old Moon, forming a nice triangle with Regulus (see Sky View).

URANUS, in Aquarius, is high in the northern sky as it transits the meridian at 9pm mid-month. At the beginning of October, Uranus is 0.5 degrees from the 4th magnitude star Lambda (λ) Aquarii, a handy pointer to find Uranus in city skies with binoculars. Uranus entered the boundaries of Aquarius early in 2003, and this constellation remains home until March 2009 when the planet crosses over into Pisces.

NEPTUNE, in retrograde motion since May, returns to its west to east motion against the star field late in the month. The planet is high in the northern sky in Capricornus at the end of astronomical twilight.

PLUTO, moving toward conjunction in mid-December, sets in the evening around 10:30pm mid-month.

DIARY

1st		Uranus 0.4°SE of star Lambda Aquarii
1st		m.p. 63 Ausonia 0.4°NW of M4 (GC) in Scorpius
3rd	3am	(1am WST) m.p. 22 Kalliope 0.1°N of IC 2157 (OC) in Gemini
3rd		m.p. 63 Ausonia 0.3°SW of NGC 6144 (GC) in Scorpius
3rd	5pm	(3pm WST) Neptune 3°N of Moon
4th		m.p. 63 Ausonia 0.15°NW of Antares
5th	10am	(8am WST) Uranus 0.5°N of Moon Occn.
6th	6am	(4am WST) m.p. 1 Ceres stationary
6th		m.p. 22 Kalliope 0.3°N of NGC 2158 (OC) in Gemini
6th		m.p. 97 Klotho 0.8°NE of star Betelgeuse
6th	Midnight	(10pm WST) Moon at perigee
7th	1:13pm	(11:13am WST) Full Moon
8th		m.p. 22 Kalliope 0.2°N of M35 (OC) in Gemini
13th		m.p. 532 Herculina 0.2°NE of Lagoon Neb. (M8) in Sagittarius
14th	10:26am	(8:26am WST) Last Quarter
15th		m.p. 532 Herculina 1.0°S of NGC 6546 (OC) in Sagittarius
15th		m.p. 532 Herculina 0.7°N of NGC 6544 (GC) in Sagittarius
15th	pm	m.p. 2 Pallas 0.5°SW of NGC 6633 (OC) in Ophiuchus
16th		m.p. 8 Flora 1.0°N of NGC 6235 (GC) in Ophiuchus
16th	Midnight	(10pm WST) Saturn 2°S of Moon
17th	2pm	(Noon WST) Mercury greatest elongation East (25°)
19th		m.p. 63 Ausonia 0.6°S of M19 (GC) in Ophiuchus
19th	8pm	(6pm WST) Moon at apogee
20th	4am	(2am WST) m.p. 3 Juno 0.3°N of Moon Occn.
21st		Mercury at greatest latitude South
22nd		Mercury 0.4°S of NGC 5897 (GC) in Libra
22nd		m.p. 8 Flora 1.1°N of NGC 6287 (GC) in Ophiuchus
22nd		m.p. 63 Ausonia 0.4°SW of NGC 6293 (GC) in Ophiuchus
22nd	3:14pm	(1:14pm WST) New Moon
23rd	5pm	(3pm WST) Mars in conjunction with Sun
24th		m.p. 97 Klotho 0.8°NE of NGC 2186 (OC) in Orion
24th	6pm	(4pm WST) Jupiter 5°N of Moon
24th	6pm	(4pm WST) Mercury 1.4°N of Moon
25th	Midnight	(10pm WST) Antares 0.4°N of Moon Occn.
26th	8am	(6am WST) Mercury 4°S of Jupiter
26th	pm	m.p. 2 Pallas 1.0°SW of IC 4756 (OC) in Serpens
27th		m.p. 532 Herculina 0.2°W of M28 (GC) in Sagittarius
28th	4am	(2am WST) Venus in superior conjunction
28th		m.p. 63 Ausonia 0.7°S of NGC 6355 (GC) in Ophiuchus
28th	Midnight	(10pm WST) Mercury 4°S of Jupiter
29th	10am	(8am WST) Mercury stationary
29th	5pm	(3pm WST) Neptune stationary
30th	7:25am	(5:25am WST) First Quarter
30th		m.p. 532 Herculina 0.5°N of star Lambda Sagittarii
30th	Midnight	(10pm WST) Neptune 3°N of Moon

MINOR PLANETS. On the 24th, 5 Astraea reaches opposition at magnitude 10.3 in Pisces. On the morning of the 8th, 22 Kalliope can be seen on the northern edge of the open star cluster M35. This new 11th magnitude 'star' may be hard to pick, but images taken 30 minutes apart or sketches over an hour or two may nail it. During October a faint (12th magnitude) 63 Ausonia tours a number of globular clusters in Scorpius and Ophiuchus. 532 Herculina visits a number of star clusters in Sagittarius.

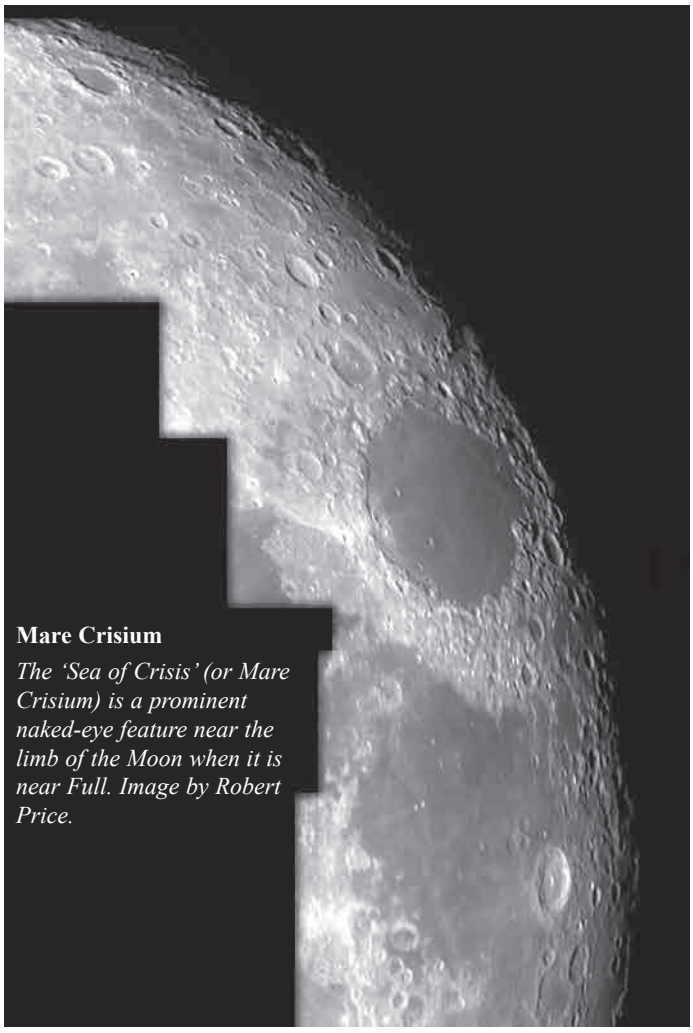
COMETS

Comet 4P/Faye moves virtually due south through Aries and Cetus during October. Expected to remain around 10th magnitude, Faye passes through perigee (0.7 AU) this month. Rising around the end of astronomical twilight, the comet will be visible all night.

Comet 73P/Schwassmann-Wachmann 3-C should fade below 12th magnitude in October. Visible all night, the comet spends most of October within a few degrees of Beta Ceti.

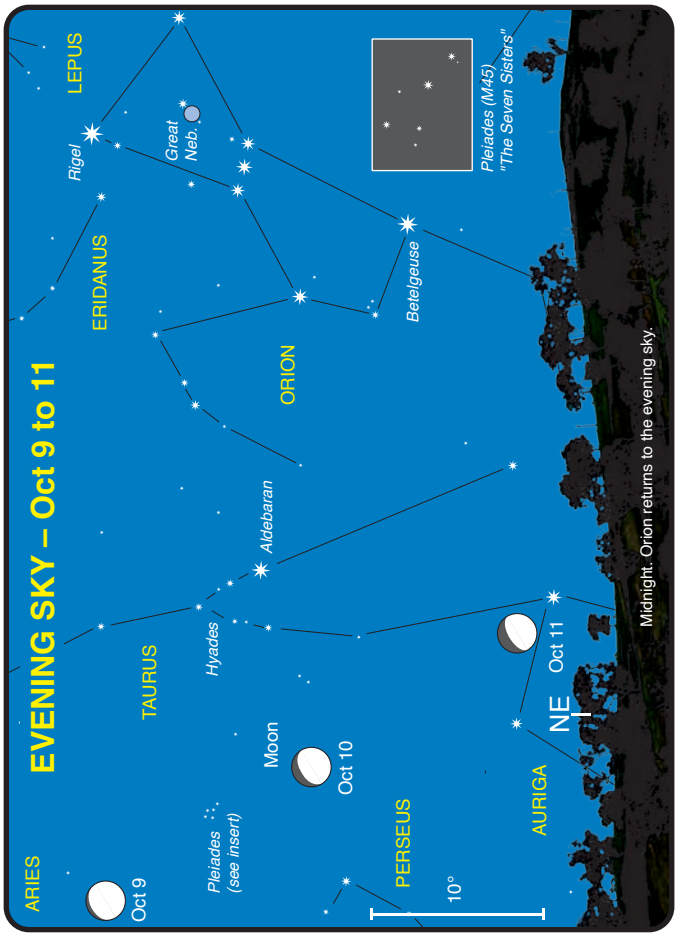
METEOR SHOWERS

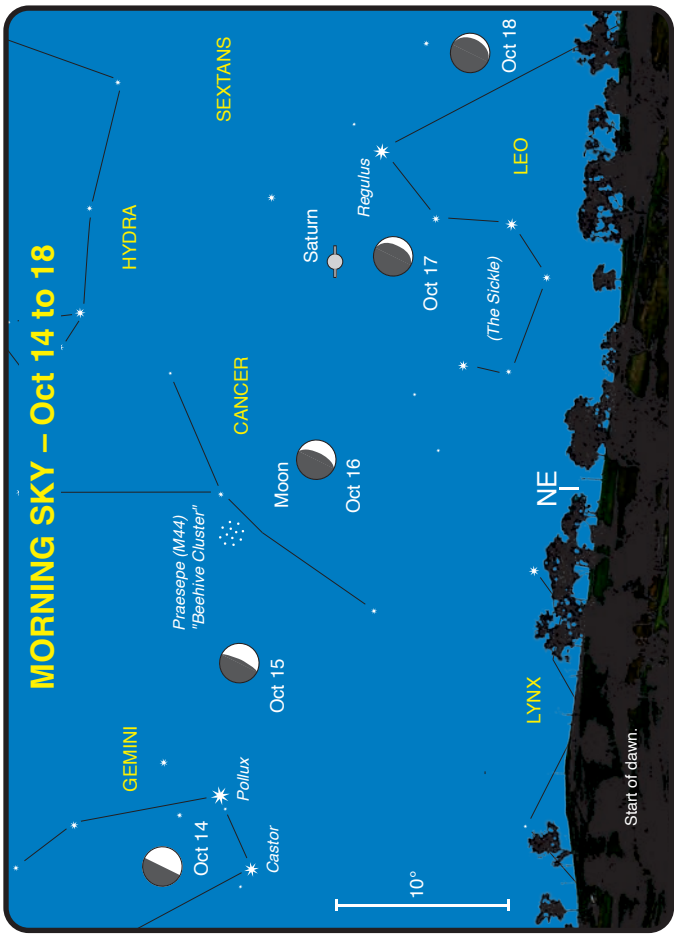
The **Orionids** are best seen from late evening until dawn and are visible from 2nd October through to 7th November. Maximum activity is on the 21st, but with many sub-maxima good rates can be observable on several consecutive nights around this date. The Orionids provide a prominent display that has over the past twenty years produced rates of 14 to 31 meteors per hour; they are typically very swift, often bright with some leaving trains. The shower was first recorded by Chinese observers in 288AD, and is associated with Halley's Comet. Conditions are ideal this year with New Moon on the 22nd.



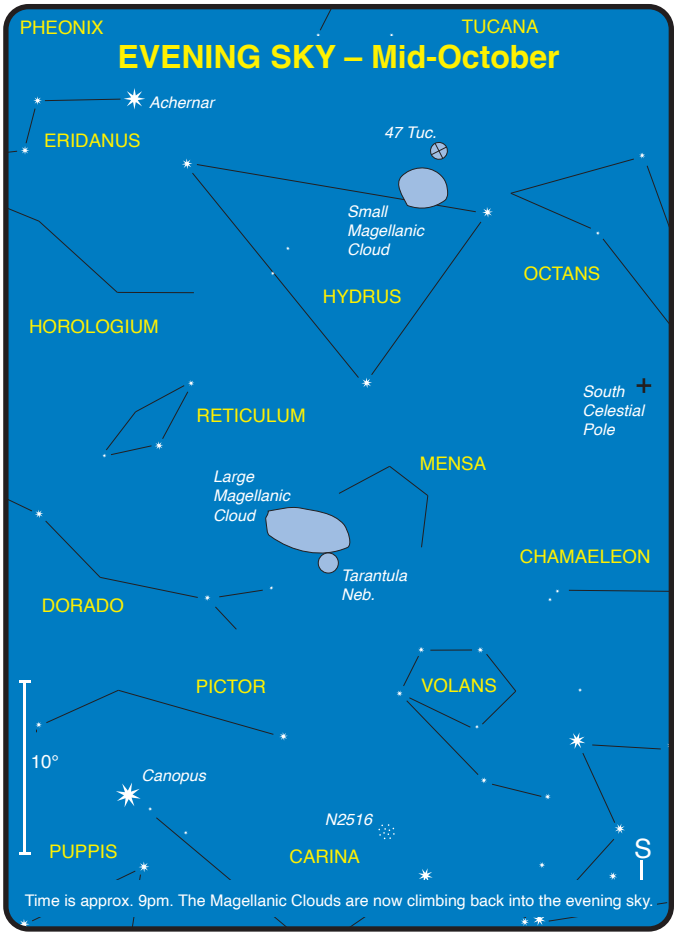
Mare Crisium

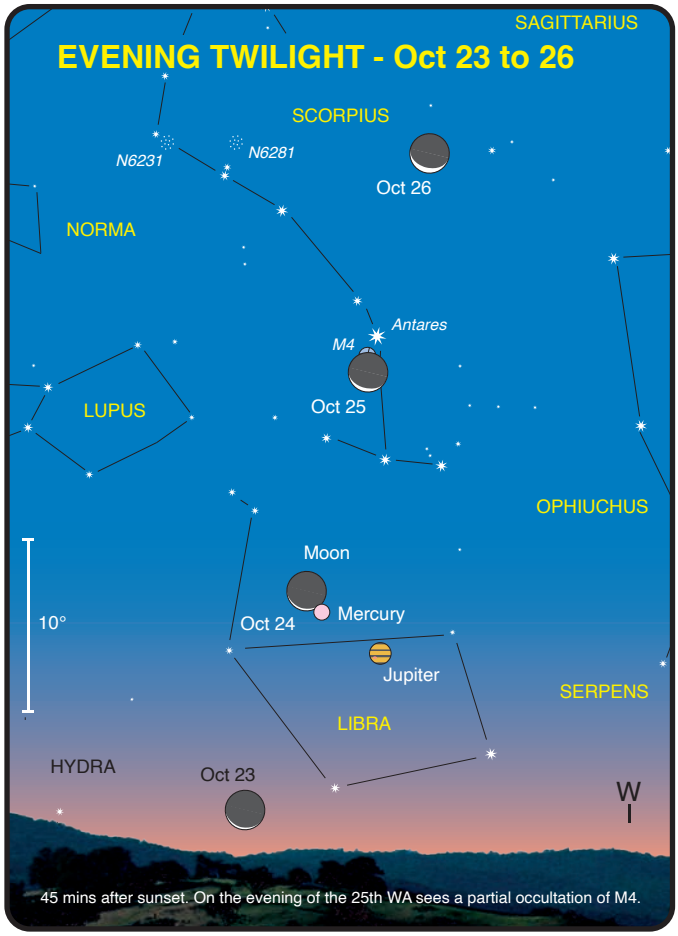
The 'Sea of Crisis' (or Mare Crisium) is a prominent naked-eye feature near the limb of the Moon when it is near Full. Image by Robert Price.





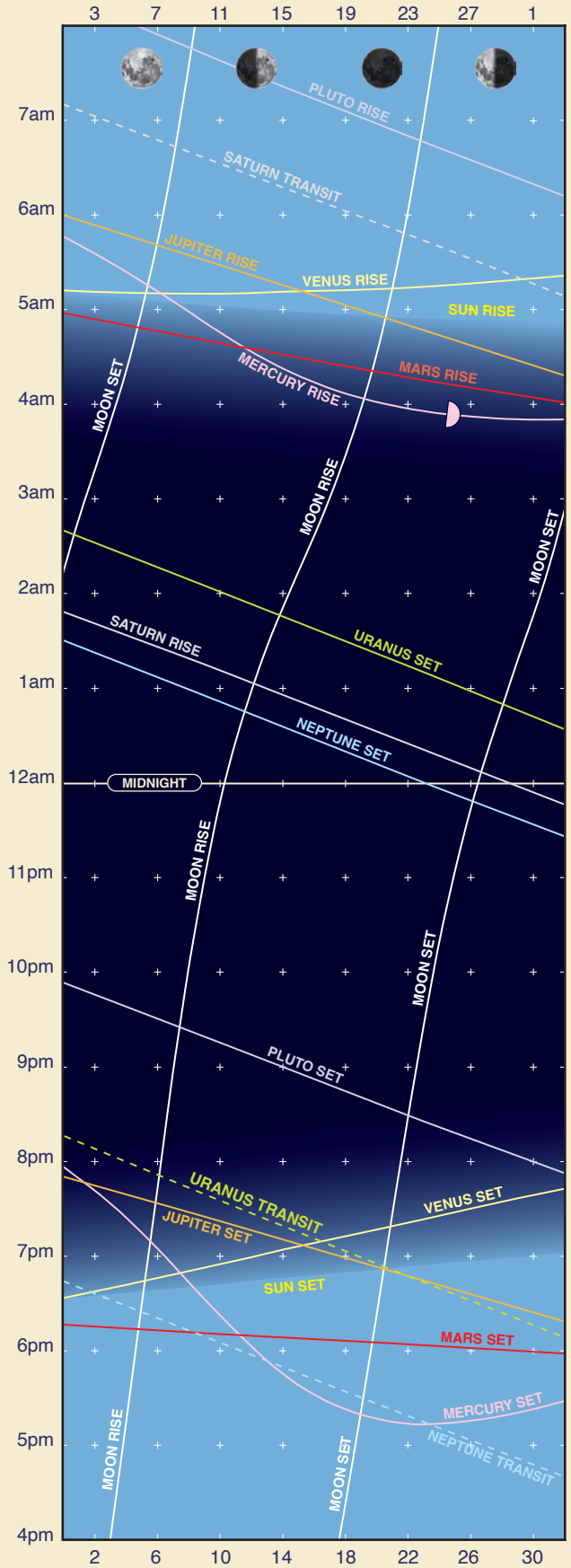
Approximate local standard time, for daylight saving add 1 hour.





NOVEMBER

RISE/SET CHART



Approximate local standard time, for daylight saving add 1 hour.

HIGHLIGHTS

- Uranus close to Moon.
- Transit of Mercury.
- Venus returns to the evening twilight sky.

THE MOON

1st Occultation of Uranus by the Moon. Visible from New Zealand, daytime event for Australia. For the eastern states the planet will be less than 1° from the bright lunar limb at the end of astronomical twilight.

4th Moon at perigee (closest to Earth – 360,596 km distant, angular size 32.6').

5th Full Moon.

13th Last Quarter.

16th Moon at apogee (furthest from Earth – 405,194 km distant, angular size 29.9').

18th Occultation of Spica by the Moon, not visible from Australia.

21st New Moon.

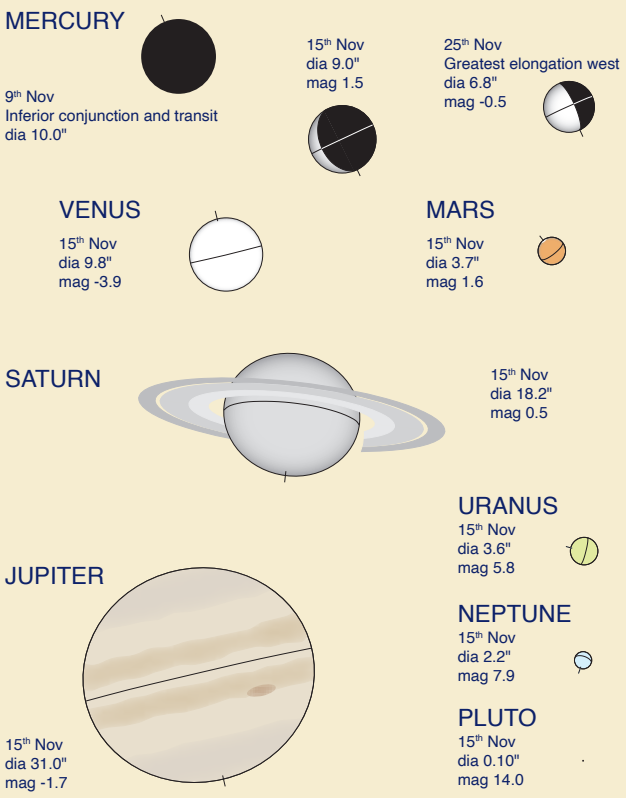
28th First Quarter.

29th EST (28th WST) Occultation of Uranus by the Moon, not visible from Australia.

THE PLANETS

MERCURY is visible in the evening twilight sky near Jupiter for the first few days of November; the planet then makes a rapid descent back toward the Sun and inferior conjunction (between the Earth and Sun) on the 9th. At this particular conjunction Mercury will transit (cross over) the Sun's disc for the first time since May 2003, the next such occurrence will be almost ten years from now in May 2016. From New Zealand and most of the eastern seaboard of Australia (except far north Queensland) the event be can be seen from start to finish. From the rest of Australia the transit will already be in progress as the Sun rises. Warning, never look directly at the Sun! The transit should only be observed by experienced observers,

APPEARANCE of the PLANETS



using safe solar observing techniques. For full details of the transit see Part II. After transit, Mercury returns to the dawn sky and reaches its greatest elongation west of the Sun (20°) on the 25th. Mercury remains a morning object for the rest of the year.

VENUS returns to the western evening twilight sky this month, its proximity to the Sun making it difficult to glimpse until month end. Any Jovian inhabitants that may be observing the Sun on the 12th will witness a rare transit of Venus across the Sun.

MARS returns to the eastern morning sky this month, although observation in the dawn will be difficult until the end of November.

JUPITER, in Libra, is visible for a short period in the evening twilight sky early in the month. It opens November with Mercury 3° away. On the 22nd, the planet will be in conjunction with the Sun, and will reappear in the morning sky in December.

SATURN, in Leo, rises around 1am mid-month. Early in November it is 6° from the 1st magnitude star Regulus (Alpha Leonis), the gap closing to 5° at month end. On the 13th, the Last Quarter Moon appears north of the planet (see Sky View).

URANUS is high in the northern evening sky, crossing the meridian about the end of twilight. In retrograde motion since June, it returns to its west to east motion against the background star field. We normally do not mention close approaches of the Moon to Uranus and Neptune since these lack the unaided visual appeal of the brighter planets. However, on the 1st from the eastern states Uranus will be less than 1° from the bright lunar limb at the end of twilight, but you will need binoculars to see the planet. Do not confuse the 4th magnitude star Lambda (λ) Aquarii with Uranus; Lambda is brighter and closer to the Moon. Uranus spends the month 1° southeast of Lambda.

NEPTUNE, in Capricornus, is in the northwestern sky at the end of astronomical twilight.

PLUTO, in conjunction with the Sun in mid-December, becomes lost in the evening twilight late in the month. This distant planet returns to the morning sky in the New Year.

MINOR PLANETS at opposition this month include: 48 Doris on the 4th at magnitude 10.9 in Cetus, 451 Patientia on the 13th at magnitude 10.7 in Cetus and 7 Iris on the 14th at magnitude 6.8 in Aries.

TRANSIT TRIVIA

After reading this article some of you might think a better title might have been 'Transit Madness' or just 'A Glut of Useless Information!' One thing you can be assured of, this has nothing to do with the transit authorities for if the Universe was as reliable as our trains and buses, this work would not be possible.

Mercury Transits

We have a transit of Mercury across the disc of the Sun on November 8. By definition, the Sun, Mercury and Earth make a straight line at this time. If we looked at the Solar System bodies that are at opposition at this time (if you like extending the line) there is a chance a double transit might be visible. Jean Meeus, in his three Astronomical Morsels books, has considered this question, and many other unusual topics. He has found that asteroid 6003 (1988 VO1) indeed sees this event, well for half an hour anyway; Mercury exits 30 minutes after the Earth enters.

A unique opportunity exists to see a double transit of Mercury this year. The first occurs on March 26. The only catch is you need to be on Jupiter to see it (maybe one of its satellites?). Jupiter doesn't see the November transit of Mercury that we do on the 8th, but, if you can get back to Jupiter again by the 12th you will witness an even more rare event, a transit of Venus.

November 8 is the first transit of Mercury seen from Earth since May 7, 2003. If you had been able to journey to Venus in 2005 you would have seen one on November 17, assuming of course you have a clear day to observe it — which is highly unlikely. While we are delving into the obscure, perhaps it's not a bad time to mention that the minor planet 449 Hamburga would have seen a simultaneous transit of Mercury and Venus on that day.

Mercury and Venus Transiting together?

However you don't have to leave the Earth to see a simultaneous transit of Mercury and Venus. It just takes a bit of patience. So mark this date on your calendar, September 17, 13425 AD (I don't know about you but my electronic organiser doesn't go that far!)

Seriously, the reasons you have to wait this long are as follows. As mentioned in the transit of Mercury section, a transit can only happen when:

1. The body (Venus or Mercury) is at inferior conjunction (i.e., passing between us and the Sun)
2. Inferior conjunction happens when the body is close to one of its nodes. This is when the object passes through the plane of the Earth's orbit or ecliptic.

Point 2 is why we only see Mercury transits around May 8 and November 8. Venus dates are June 8 and December 8. So we have to wait for the orbits of both planets to precess until two of their nodes coincide. Astronomically speaking, having to wait 11,419 years is nothing. On the human scale, well …

And for Something Different

A normal transit of Mercury is pretty commonplace — for example if you miss the November 8 event there are 12 more opportunities this century. If you want something a little different, how about a Mercury transit during a partial solar eclipse? You only have to wait until July 5, 6757AD. If you really want to hold out you can see a transit of Venus during a total solar eclipse on April 5, 15232AD.

Transit of Venus in 2012

The transit of June 6, 2012 couldn't be better placed for observers in eastern Australia, with mid-transit occurring at 11:30am EST (9:30am WST). Observers west of Adelaide will unfortunately miss the first two contacts with the transit well underway at sunrise. However, if weather troubles you it is your last opportunity for the century. The same can be said for any Jovians observing in 2012. They see a Venus transit on September 20 but this is their last chance for the century as well. So if you have any friends out around Jupiter warn them! Unfortunately for the Jovians, their view of Venus is a poor 4 arc seconds in diameter, compared to our 58 arc seconds.

One place to observe the transit where weather would not be a problem is on the minor planet 128 Nemesis. On June 6, 2012 you would not only see Venus transit but the Earth and Moon as well! Just a warning to give you time to make your travel plans.

References: Meeus: Mathematical Astronomy Morsels
Meeus: More Mathematical Astronomy Morsels.
Meeus: Mathematical Astronomy Morsels III

A 'bird's-eye' view of the Transit of Venus in 2003
Taken by Ken Wallace from Marulan, NSW, using a Nikon 5700 Coolpix digital camera at prime focus of a 100mm Bosch and Lomb Schmidt Cassegrain Telescope, equipped with a full aperture solar filter.

COMETS

Comet P/1991 V1 (Shoemaker-Levy 6) begins November near Theta-1 Sagittarii. The comet is at 13th magnitude this month, moving through Sagittarius, Microscopium, Capricornus, and Aquarius. Reaching both perihelion (1.1 AU) and perigee this month (0.8 AU), Shoemaker-Levy 6 will be visible until late evening. On 23rd November, the comet will be in the same low-power field as the globular M30.

Comet 4P/Faye reaches perihelion mid-month, at 1.7 AU from the Sun. Moving south through Cetus, Faye should remain around 10th magnitude throughout November and will be visible until early morning each night.

METEOR SHOWERS

The **Leonids**, after a storm of unbelievable intensity in 1833, were responsible for the change in scientists' attitudes that meteors were not purely an atmospheric event. The shower is associated with the periodic comet 55P/Tempel-Tuttle and is best about every 33 years when the comet returns to perihelion. Between 1998 and 2002 they put on spectacular displays, but have been quiet since. Predictions for 2006 are for improved zenith hourly rates around 100 to 150. They are active from 14th to 21st November, with the maximum predicted for the afternoon of the 19th (EST). For those unable to travel to eastern Americas, western Europe or Africa, the best time here will be on the morning of the 19th or 20th.

The **alpha-Monocerotids** is a minor shower, with unusual short-lived bursts of high rates. Active from 15th to 25th November, they peak on the 21st and are best seen during late evening. While the zenith hourly rate is normally around 5, high rates were seen in 1925, 1935 & 1985. In 1995 it reached an estimated 420, lasting just 5 minutes, the entire shower was over in 30 minutes.

DIARY

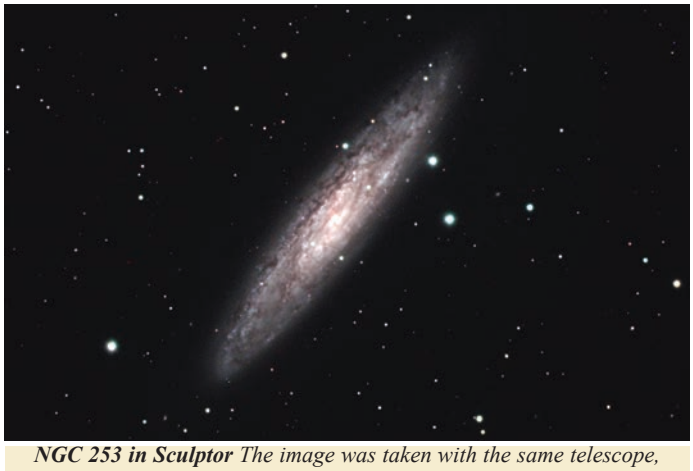
1st	6pm	(4pm WST) Uranus 0.5°N of Moon Occn.
4th	10am	(8am WST) Moon at perigee
5th		m.p. 532 Herculina 1.1°S of M22 (GC) in Sagittarius
5th	10:58pm	(8:58pm WST) Full Moon
9th	8am	(6am WST) Mercury in inferior conjunction, transit over Sun
9th		Mercury at ascending node
12th		m.p. 44 Nysa 0.4°SW of NGC 2304 (OC) in Gemini
12th	Noon	(10am WST) Transit of Venus across the Sun (from Jupiter)
13th	3:45am	(1:45am WST) Last Quarter
13th		Mercury at perihelion
13th	11am	(9am WST) Saturn 1.6°S of Moon
16th	9am	(7am WST) Moon at apogee
17th		m.p. 63 Ausonia 0.8°S of NGC 6553 (GC) in Sagittarius
17th		m.p. 532 Herculina 1.0°N of star Sigma Sagittarii
17th		m.p. 15 Eunomia 0.1°W of star Epsilon Aquarii
18th	5am	(3am WST) Mercury stationary
18th		m.p. 3 Juno 0.8°NE of NGC 4546 (LG) in Virgo
18th	1pm	(11am WST) Spica 0.6°N of Moon Occn.
19th	11pm	(9pm WST) Mercury 6°N of Moon
20th	9pm	(7pm WST) m.p. 8 Flora 0.3°NW of Trifid Neb. (M20) in Sagittarius
20th	pm	m.p. 6 Hebe 0.5°N of M30 (GC) in Capricornus
20th	Midnight	(10pm WST) Uranus stationary
21st	8:18am	(6:18am WST) New Moon
21st	pm	m.p. 2 Pallas 0.3°NE of NGC 6749 (GC) in Aquila
22nd	9am	(7am WST) Jupiter in conjunction with Sun
22nd		m.p. 8 Flora 0.5°S of M21 (OC) in Sagittarius
23rd		m.p. 8 Flora 0.4°N of NGC 6546 (OC) in Sagittarius
23rd		Venus at descending node
23rd	pm	Comet P/1991 V1 (Shoemaker-Levy 6) 0.6°N of M30 (GC) in Capricornus
24th		m.p. 63 Ausonia 1.0°S of star Lambda Sagittarii
24th		Mercury at greatest latitude North
24th	pm	Comet P/1991 V1 (Shoemaker-Levy 6) 0.7°NW of m.p. 6 Hebe
24th	pm	m.p. 39 Laetitia 0.2°N of star Pi 4 Orionis
25th		m.p. 1 Ceres 1.4°SE of M30 (GC) in Capricornus
25th	11pm	(9pm WST) Mercury greatest elongation West (20°)
26th		m.p. 3 Juno 0.5°NE of NGC 4691 (SG) in Virgo
26th		m.p. 63 Ausonia 0.8°S of NGC 6638 (GC) in Sagittarius
26th	pm	m.p. 2 Pallas 0.6°N of NGC 6760 (GC) in Aquila
27th	7am	(5am WST) Neptune 3°N of Moon
28th	4:29pm	(2:29pm WST) First Quarter
29th	1am	(11pm WST, prev day) Uranus 0.3°N of Moon Occn.

BINOCULAR GALAXIES

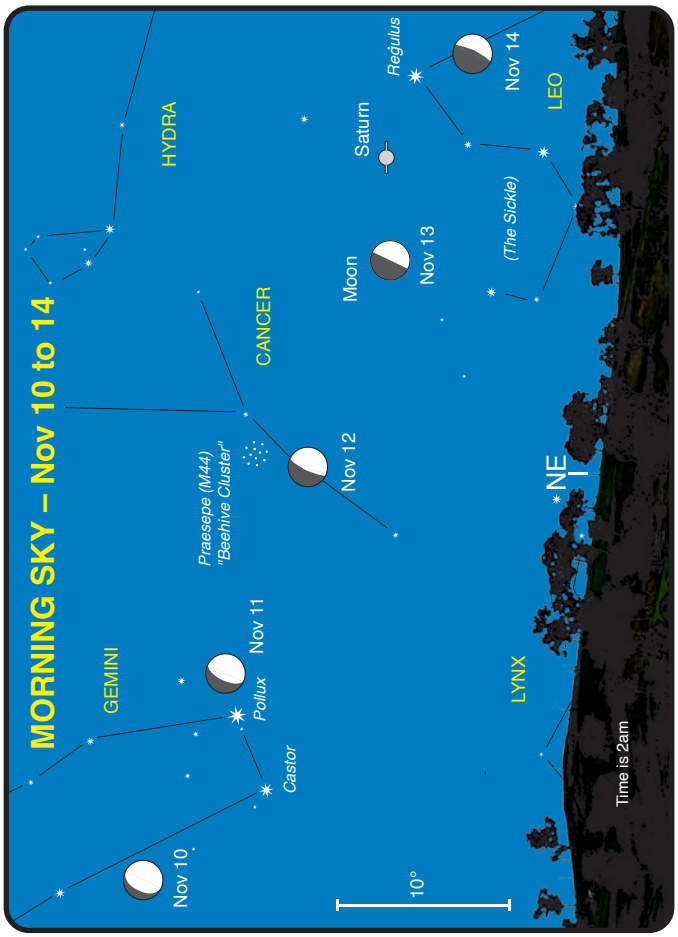
Living in the Southern Hemisphere we are fortunate to be able to view the Magellanic Clouds, which make great binocular viewing. In our Binoculars article (page 15) two other galaxies mentioned as being challenges for binoculars are M33 and NGC 253. November is an ideal time of the year to observe these objects, with both being high in the sky in the mid-evening. M33 is a particular challenge. It is a face-on spiral and has a low surface brightness as can seen in the image below. In fact, in a small telescope it can fill the field of view and not be obvious at all! The wide field of a pair of binoculars makes it easier to see this ghostly patch in Triangulum (see All Sky Map No. 3). A dark, moonless sky is needed and you would probably need to see the Andromeda Galaxy (M31) with the naked-eye to have a chance at M33 with binoculars. M33 is 15° to the upper right (southeast) of M31. M33 also has another aspect to its challenge, with a declination of +31°, it only gets about 20° to 25° above the northern horizon from mid-latitudes in Australia. At low altitudes like this, the thickness of the atmosphere can dull the appearance of nebulous objects like galaxies. On the other hand, although NGC 253, in Sculptor, is considered fainter than M33, it is an edge on spiral (see bottom image) and has a higher surface brightness. It is also very high in the sky from Australian latitudes (see All Sky May No. 2), meaning you are looking through less atmosphere.

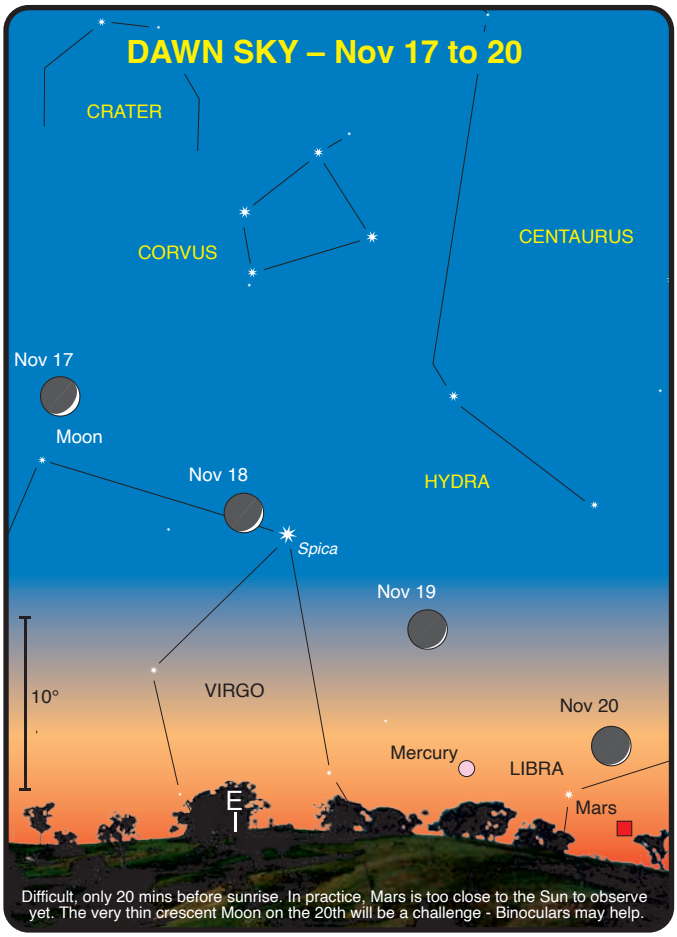
The following images highlight the wonderful work done by Brisbane astrophotographer Max Kilmister.

M33 in Triangulum *The image is a single 60-minute exposure on Kodak Ektachrome E200 slide film. The telescope was his 128mm Takahashi refractor on a Takahashi EM200 mount, and with a focal reducer giving a focal ratio of f/6. It was autoguided by an SBIG ST4 CCD camera.*

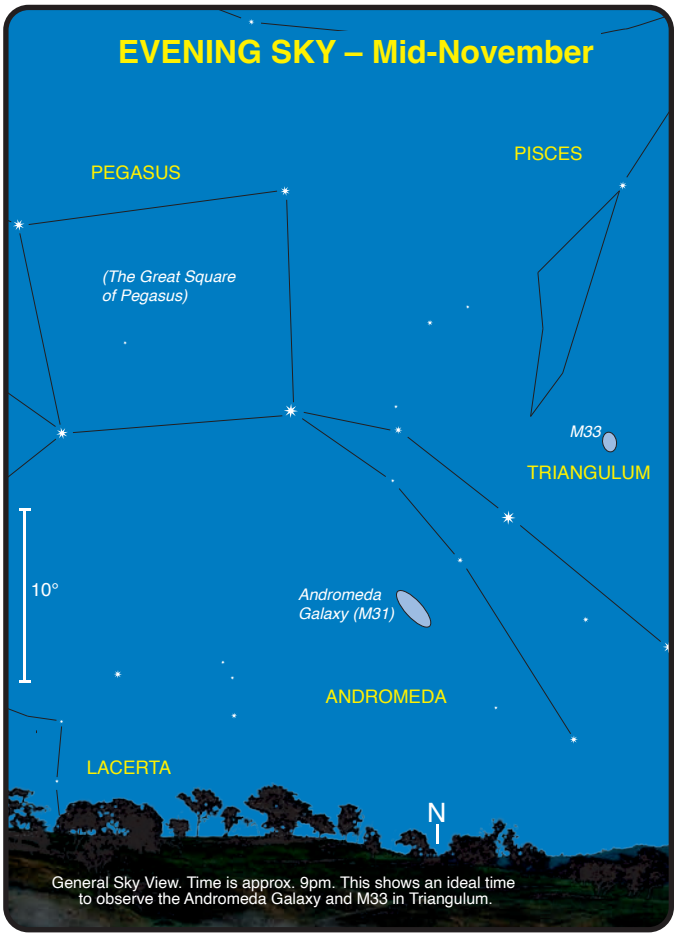


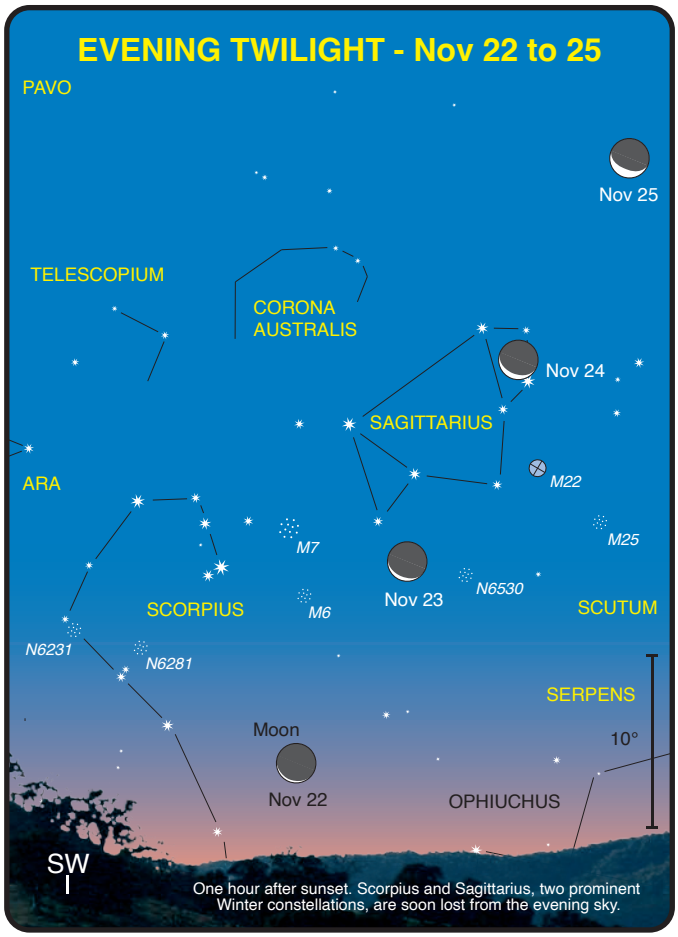
NGC 253 in Sculptor *The image was taken with the same telescope, mount, focal reducer and autoguider as the M33 image using a Starlight Xpress CCD camera. It comprises two 500-second unbinned luminance images and two 100-second images of each of the RGB colours binned 2 x 2. It was processed using MaxIm DL and Photoshop.*





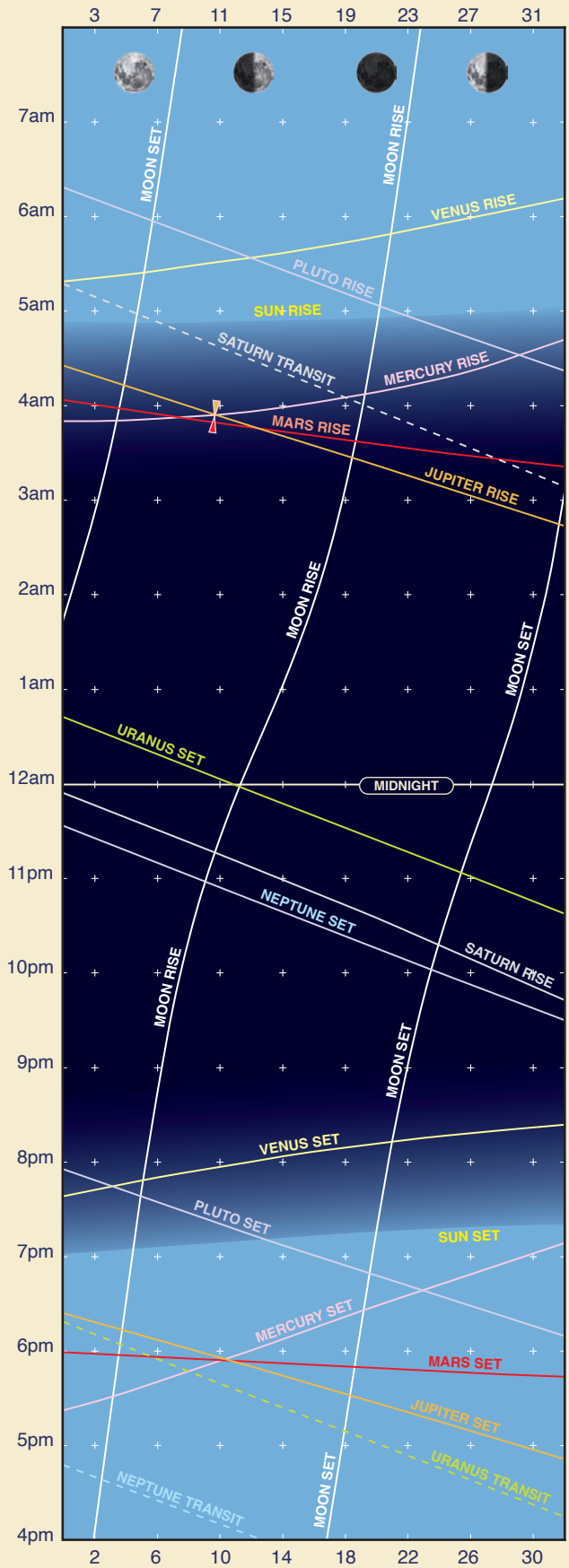
Approximate local standard time, for daylight saving add 1 hour.





DECEMBER

RISE/SET CHART



Approximate local standard time, for daylight saving add 1 hour.

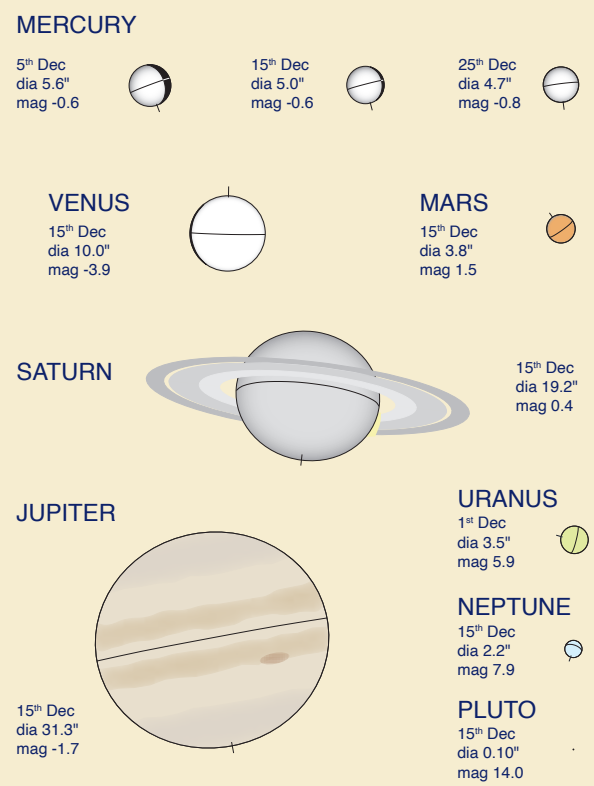
HIGHLIGHTS

- Rare triple planet grouping of Mercury, Mars and Jupiter.
- Venus returns to the evening twilight.
- Saturn and Moon close.

THE MOON

2nd	Moon at perigee (closest to Earth – 365,923 km, size 32.1').
5th	Full Moon.
10th	Occultation of Saturn by the Moon, not visible from Australia.
13th	EST (12th WST) Last Quarter.
14th	Moon at apogee (furthest from Earth – 404,418 km distant, angular size 29.9').
15th	Occultation of Spica by the Moon, not visible from Australia.
19th	Occultation of Antares by the Moon, daytime event from southeast Australia.
21st	EST (20th WST) New Moon.
26th	Occultation of Uranus by the Moon, not visible from Australia.
28th	EST (27th WST) First Quarter.
28th	Moon at perigee (closest to Earth – 370,323 km, size 32.2').

APPEARANCE of the PLANETS



THE PLANETS

MERCURY begins the month in Libra together with Mars and Jupiter low in the dawn eastern sky (see Sky View). The three planets converge on a point over the border in Scorpius, forming a rare triple planetary grouping. The action occurs near the 2.5 magnitude star Beta (β^1) Scorpii from the 10th to the 12th. On the 10th, a neat triangle is formed with the planets fitting in a 1.2° diameter circle. On the next morning, the planets form a straight line, fitting into a 1° circle (Mercury and Jupiter just 0.2° apart). On the 12th, they make another triangle, with the planets fitting into a 1.5° circle. After the rendezvous, Mercury rapidly moves away from Mars and Jupiter, and by month end the planet will be lost in the Sun's glare, reappearing in the evening sky in the New Year.

VENUS is now easily visible in the western evening twilight sky soon after sunset. The planet spends the first week of December in Ophiuchus, and the rest of the month in Sagittarius.

EARTH is at Solstice on the 22nd when the days are longest. On this day the Sun is at its most southerly position with a declination of –23.5°.

MARS, in the eastern dawn sky, moves through Libra, Scorpius and into Ophiuchus during December. The planet plays a role, with Mercury and Jupiter, in the planet assemblage from the 10th to the 12th (see

THE STAR OF BETHLEHEM

One of the most eternal symbols associated with the birth of Christ is the Star of Bethlehem that supposedly led the Wise Men (Magi) to the manger in the stable. Scholars have been fascinated in its origin for a long time. For this article we have made a number of assumptions:

1. That the story has some historical basis in fact,
2. That historians have done a reasonable job in getting the timing right, and
3. Another leap of faith (if you will excuse the expression) that the 'Star' is based on actual astronomical event(s).

Even if your religious belief excludes the possibility of the Star being anything but a divine, supernatural event, think of this as an essay about a brief time in history, which contained a number of extraordinary planetary alignments.

Historians are fairly confident about points 1 and 2 and believe the nativity occurred sometime between 7BC and 1BC. It is not surprising the 'Star' would be taken so seriously by people of this time for they were very interested in the significance of astronomical events and there was a fine line between astronomy and astrology. The Magi were widely recognised as true astronomers/astrologers and had an aura of mysticism about them. The Jews were very superstitious and had high respect for these scholars. In fact, the word 'Magi' is plural for 'Magus' which is the origin of 'magic'.

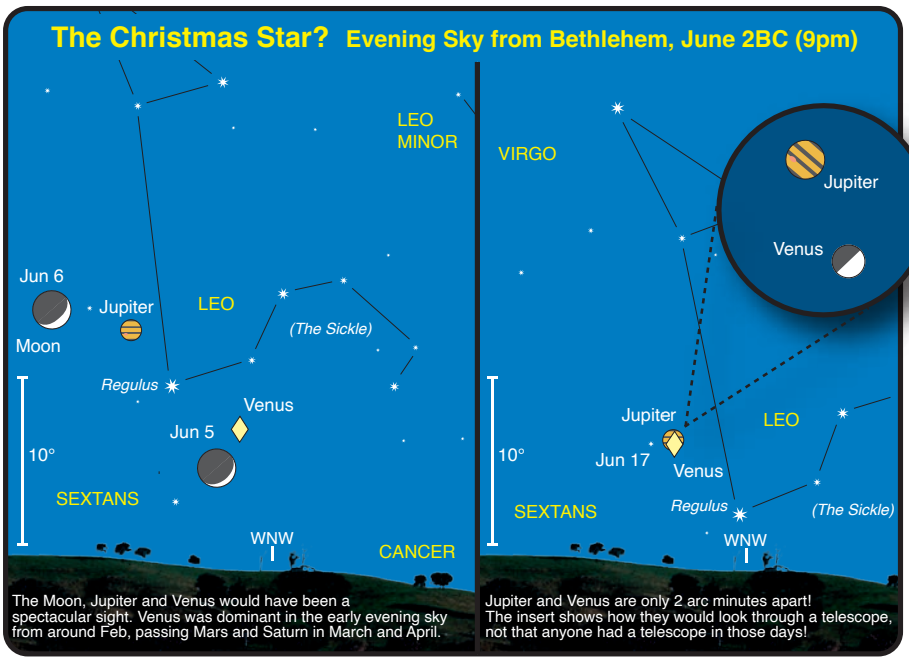
During this time there were two bright comets, one in 5BC, the other in 4BC. Persian and Romans considered comets to foretell disasters and the last thing they would herald would be the birth of the Jewish Messiah.

The years 3BC and 2BC had a remarkable series of conjunctions, a group of events that even today are some thousands of years away from being repeated.

1. Saturn and Mercury 1° apart on May 19, 3BC, in Taurus.
2. Saturn and Venus on June 12, 3BC, were 9 arc minutes apart in the dawn sky in Taurus.
3. Jupiter and Venus, on August 12, 3BC, were only 9 arc minutes apart in the dawn sky in Leo.
4. Jupiter and Venus met again on June 17, 2BC, only 2 arc minutes apart, in Leo, in the evening sky (see diagram). It is interesting that the planets, as seen from the Middle East, set before their closest approach. Europe (and further west) would have seen them considerably less than 1 arc minute apart, with perhaps part of Venus covering Jupiter! (Well … if telescopes had existed)

Astrologers had a field day over these events. Event No. 3 would have been impressive enough, the 'King Planet', Jupiter, involved in this brilliant event in the 'Royal' constellation, Leo. Besides the regal connection, Leo also held a special relationship with the Jews, being the 'Lion of Judea'. This could have heightened the Magi to look for further signs, and that's exactly what they got. Jupiter, due to its retrograde motion, had three close encounters with Regulus on September 12 3BC (15 arc minutes), February 17 2BC (47') and May 8 2BC (38') — Regulus being the 'King star'! This was followed by the close conjunction No. 4, which, when you consider the glare, would have made for one brilliant 'single star'. Unfortunately we can only give a superficial overview here, but even the fact that this conjunction occurred during a Full Moon was significant to the Romans. The day of Full Moon was sacred to Jupiter, being called the 'Trust of Jupiter'.

So Why December 25? This date has nothing to do with the nativity, for the actual date is long lost in history. For the first couple of centuries AD the birth of Christ was rarely recognised by the church at all, for the concept of celebrating birthdays was considered a pagan practice. When the church finally got over this concern, various dates were considered, a number with a common theme, which jointly celebrated God's Son and the celestial Sun. In 243AD, the date of March 21 was pushed because it was considered to be the day God created the Sun. December 25 was eventually selected, and first celebrated by western Christians in 336AD, perhaps the ultimate convergence between the church and paganism. This date already had two festivals in keeping with the Sun theme, the 'birth of the unconquered Sun' (a Roman celebration) and the Iranian 'Sun of Righteousness' (the timing was influenced by the Winter Solstice being only a few days earlier). Seeing that the pagans seemed to be worshipping a celestial body, which had for sometime been loosely connected to Christ, the church decided to have a celebration of their own. Marry this with other previously non-Christian practices, such as giving gifts, and a tradition was born!



The Moon, Jupiter and Venus would have been a spectacular sight. Venus was dominant in the early evening sky from around Feb, passing Mars and Saturn in March and April.

Jupiter and Venus are only 2 arc minutes apart! The insert shows how they would look through a telescope, not that anyone had a telescope in those days!

Mercury above, and Sky View). Close groupings of a trio of planets (within a 5° circle) may occur several times a year, or even a few years apart. Particular close alignments between a set group of planets are not as common. From 2000 to 2100 AD there are eight instances when Mercury, Mars and Jupiter lie within a 5° circle. If we take out the times when the planets are too near the Sun (often the case when Mercury is involved) or below the horizon, we are left with just two events: this year's and one in February 2009 when the trio fit within a 4° circle.

JUPITER climbs out of the dawn sky, early in the month, to join Mercury and Mars between the 10th and 12th (see Mercury above, and Sky View). On the 19th, the slender crescent Moon, just 4% illuminated, appears near Jupiter, Mars and Antares, forming a rough 5° square (see Sky View).

SATURN rises in the late evening eastern sky just 5° north of the 1st magnitude star Regulus (Alpha Leonis). Late on the evening of the 10th, the 20-day old waning gibbous Moon appears just 2.5° below Saturn, the pair forming a neat triangle with nearby Regulus (see Sky View). Saturn reaches opposition in early February 2007, and the coming months are the best for viewing the ringed planet at its brightest and largest.

DIARY

1st	pm	m.p. 44 Nysa 0.3°N of NGC 2304 (OC) in Gemini
2nd	10am	(8am WST) Moon at perigee
3rd		Mars at descending node
3rd	pm	m.p. 6 Hebe 0.4°S of NGC 7184 (SG) in Aquarius
5th		Mercury 0.4°NW of m.p. 9 Metis
5th		m.p. 8 Flora 0.5°N of NGC 6642 (GC) in Sagittarius
5th	10:25am	(8:25am WST) Full Moon
6th		m.p. 63 Ausonia 0.6°N of star Sigma Sagittarii
7th	6am	(4am WST) Saturn stationary
7th		m.p. 8 Flora 0.9°N of M22 (GC) in Sagittarius
10th	6am	(4am WST) Mercury 1.0°N of Mars
10th	9pm	(7pm WST) Saturn 1.2°S of Moon Occn.
11th	2am	(Midnight WST, prev day) Mercury 0.1°N of Jupiter
11th		Mercury 0.4°SE of star Beta Scorpius
11th		Mars 1°S of star Beta Scorpii
12th	10am	(8am WST) Mars 0.8°S of Jupiter
12th	pm	Comet 29P/Schwassmann-Wachmann 1 1.0°S of star Zeta Persei
13th	12:32am	(10:32pm WST, prev day) Last Quarter
13th		m.p. 704 Interamnia 0.3°N of star Theta Pegasi
14th	5am	(3am WST) Moon at apogee
14th	6pm	(4pm WST) Mercury 5°N of Antares
15th	9pm	(7pm WST) Spica 0.8°N of Moon Occn.
15th	pm	m.p. 6 Hebe 1.4°NW of Helix Neb. (BN) in Aquarius
16th		m.p. 1 Ceres 1.2°SE of NGC 7184 (SG) in Aquarius
16th		m.p. 15 Eunomia 0.5°S of star Beta Aquarii
17th		Mercury at descending node
19th	1am	(11pm WST, prev day) Pluto in conjunction with Sun
19th	7am	(5am WST) Jupiter 6°N of Moon
19th	1pm	(11am WST) Mars 4°N of Antares
19th	2pm	(Noon WST) Antares 0.4°N of Moon Occn.
19th	2pm	(Noon WST) Mars 5°N of Moon
21st	12:01am	(10:01pm WST, prev day) New Moon
22nd	10am	(8am WST) Solstice
24th		m.p. 9 Metis 0.2°N of star Beta Scorpii
24th	1pm	(11am WST) Neptune 3°N of Moon
26th	7am	(5am WST) Uranus 0.08°S of Moon Occn.
27th		Mars 0.6°S of NGC 6235 (GC) in Ophiuchus
27th		Mercury at aphelion
28th	12:48am	(10:48pm WST, prev day) First Quarter
28th	Noon	(10am WST) Moon at perigee
29th	9pm	(7pm WST) Comet 4P/Faye 0.05°N of star Gamma Ceti
31st		Mars 0.4°S of NGC 6287 (GC) in Ophiuchus
31st		Uranus 0.4°S of star Lambda Aquarii
31st		m.p. 1 Ceres 1.7°NW of Helix Nebula (NGC 7293) in Aquarius
31st	Midnight	(Midnight WST) … and here endith another free trip around the Sun. Have you booked your tickets for next year?

URANUS is high in the northwestern sky at the end of astronomical twilight. In binoculars or a low power telescope field, the planet can be seen 0.8° from the 4th magnitude star Lambda Aquarii early in December and closer at 0.4° at month end.

NEPTUNE sets around 10:30pm in the western evening sky. The planet will be in conjunction with the Sun in early February 2007.

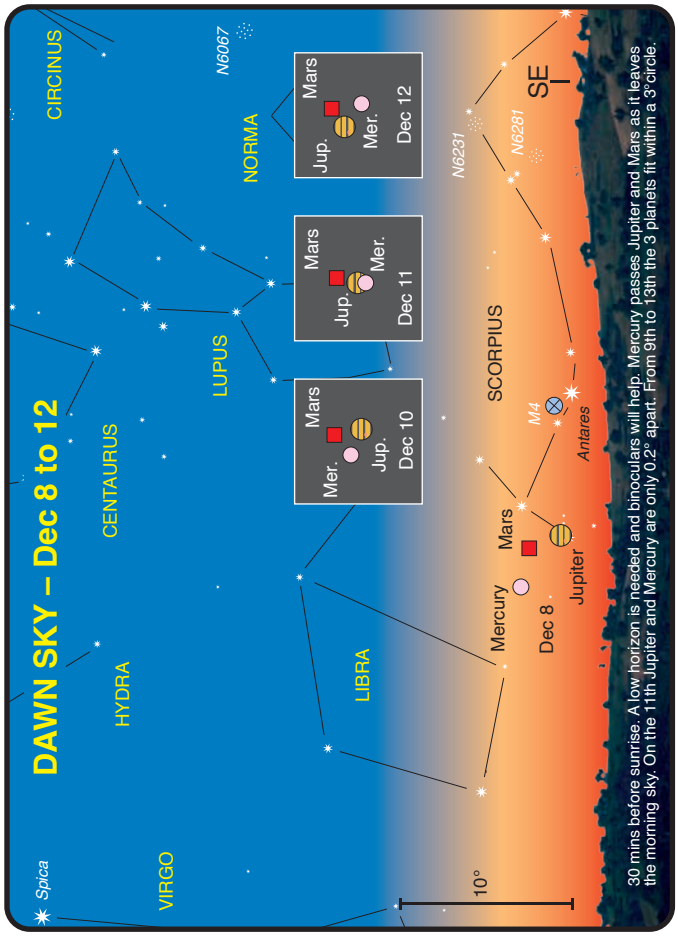
PLUTO, in conjunction with the Sun on the 19th, returns to the morning sky in the New Year. On the 5th, Pluto crosses into Sagittarius. The last time it was in this constellation was in 1774.

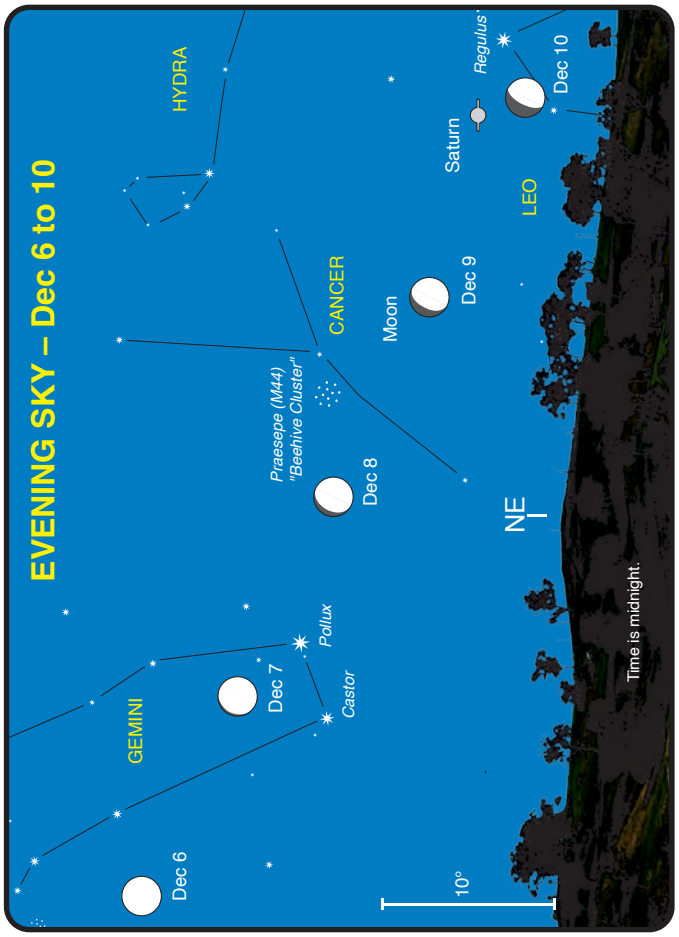
MINOR PLANETS at opposition this month include: 22 Kalliope on the 19th at magnitude 9.9 in Auriga, 97 Klotho on the 22nd at magnitude 9.9 in Orion, 44 Nysa on the 29th at magnitude 9.0 in Gemini and 39 Laetitia on the 2nd at magnitude 9.7 on the border of Orion and Taurus.

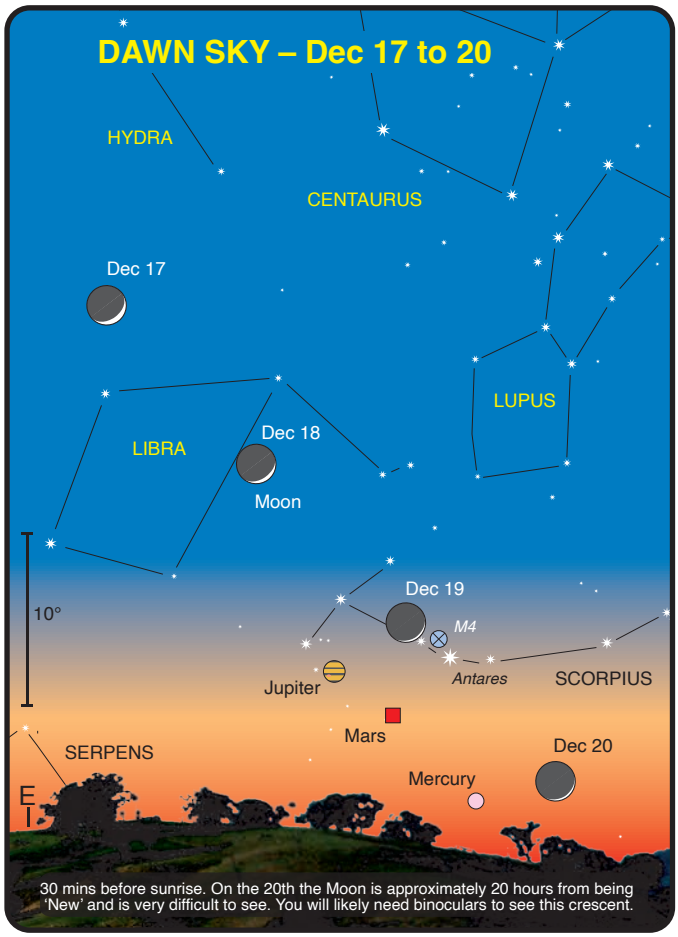
COMETS

Comet P/1991 V1 (Shoemaker-Levy 6) should fade from 13th to 14th magnitude in December as it moves away from both the Sun and Earth. Moving northeast through Aquarius and Pisces, the comet will be best observed at the end of evening twilight, as it sets around midnight. On 12th December, Shoemaker-Levy 6 will be quite close to Lambda Aquarii.

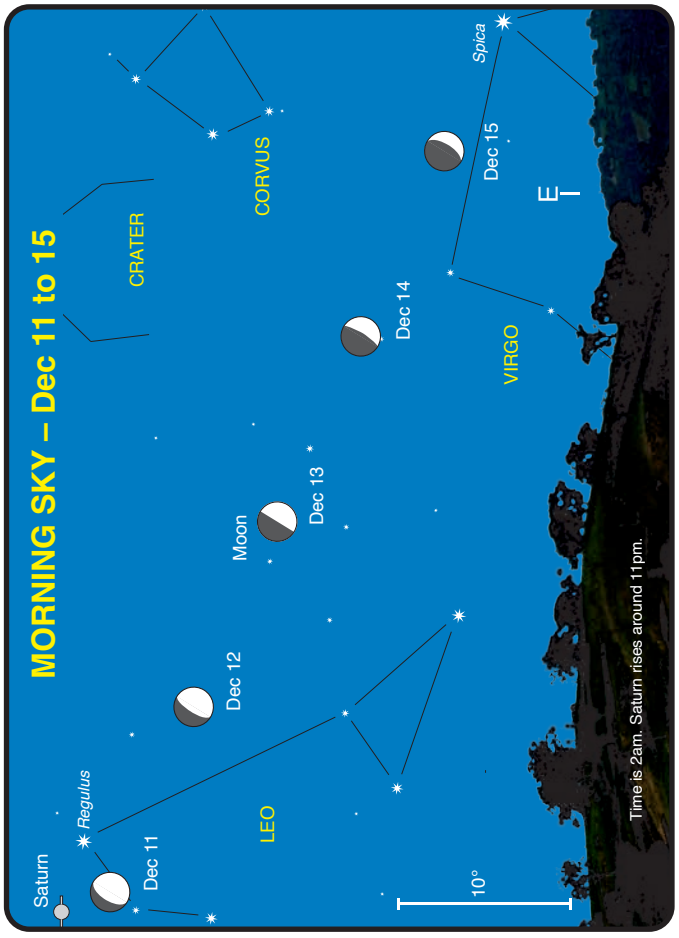
Comet 4P/Faye is expected to fade from 10th to 11th magnitude this month. Now past perihelion, the comet is moving east through Cetus and is best observed in the evening. As 2006 draws to an end, Faye can be found close to 3rd magnitude Gamma (γ) Ceti.

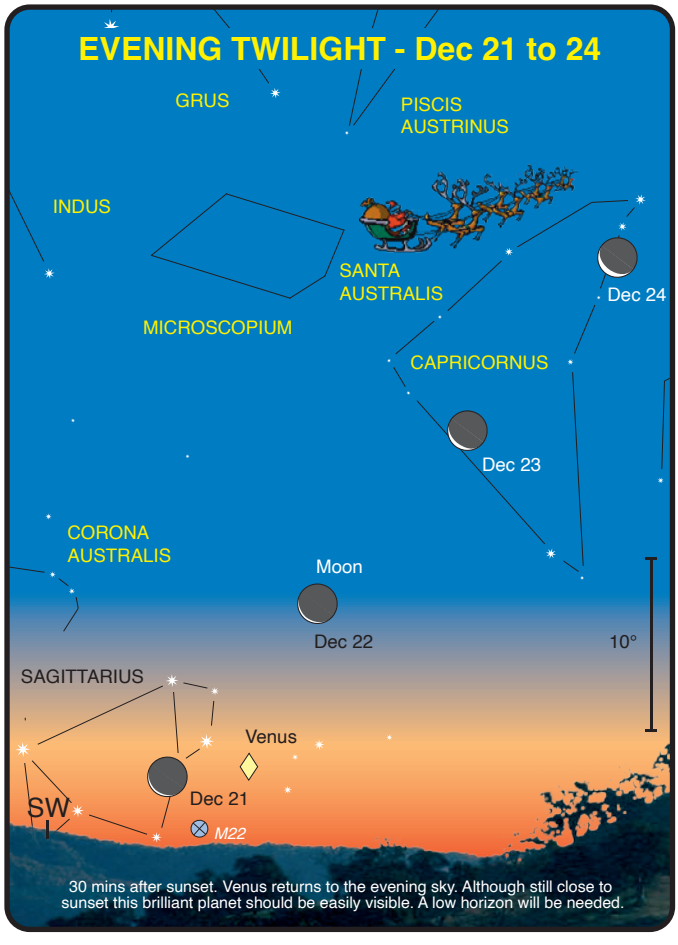






Approximate local standard time, for daylight saving add 1 hour.





ALL SKY MAPS

Introduction

These maps have been created to show you the entire night sky at any time of the year from anywhere in Australia. It is probably more accurate to say they are useful for anywhere in the Southern Hemisphere with latitudes similar to Australia. This includes most of New Zealand, South Africa and parts of South America.

Who can use them?

Anyone, and you don't even need binoculars or a telescope to become completely at ease finding your way around the sky and recognising all of the constellations.

The limiting magnitude of the charts is 5.5. If you live in a suburban area, you will not see the faintest stars marked on the maps. Some of the less conspicuous constellations may not be visible at all; a pair of binoculars will help. Under dark, country skies, where you can see the Milky Way, you will be able to see numerous fainter stars that are not marked on the maps.

How Do I Use Them?

There are nine maps. Map 1 is the far southern sky called Looking South. Then there are four pairs of maps, one pair for each season i.e., a Centre and a North map.

To use the Looking South map, face south and rotate the chart to get the correct orientation. Use a distinctive star pattern like the pointers and Southern Cross to help. From mid-Australian latitudes, and further south, Crux is circumpolar and never sets.

The rest of the maps are used as follows. Turn to the relevant season and rotate the book onto its side so the right hand North page is on the bottom and look towards the north. The northern sky, directly above the horizon, is represented on the North map and as you progress up the sky towards the overhead point (or zenith) you will cross over onto the Centre map.

The seasonal views are a little arbitrary. As you will see in the Notes section on the maps, an evening view around the relevant time of the year was chosen. However, if you are willing to stay up all night there is only a small part of the entire sky not available to you. For example, suppose it is around mid to late June. At 9pm the sky will look like the Winter pair. By 3am the sky will be showing the Spring view. Around dawn, the Earth will have rotated further, where the sky is now half Spring (to the left or towards the west) and half Summer (towards the right or east). Using a planisphere illustrates this quite well.

What does the fine black grid represent?

These are the right ascension (RA) and declination (Dec.) lines. The RA line, which starts on the due north point (N on the North charts) and runs vertically up the page, crossing through the point directly overhead and heading down to the southern horizon, is called the local central meridian. When objects cross this meridian they are said to be culminating and they have reached their highest point in the sky. Looking at the Spring (North) chart, the RA of the central meridian at 11pm on August 20 is approximately 21 hours (as an aside this is also the definition of the local sidereal time, see page 140). The constellation of Cygnus is transiting the meridian. In a couple of hours (around 1am) the star Alpha Pegasi (Markab), with an RA close to 23 hours, will culminate.

The declination indicates which areas of the charts will pass directly overhead. This is when an object has the same declination as your latitude. For example, the latitude of Hobart is nearly 43° S. Looking at the Autumn (Centre) map on March 20 at 9 pm the star Suhail, with a declination close to −43°, will be very close to the overhead point (or zenith) as seen from Hobart.

What do the dashed lines, labelled with city names, on the 'North' maps mean?

Australia is a large country and your latitude dictates how far north in the sky you can see. These lines represent the declination furthest north you can see from each of the cities. If a star is very close, but still above, your dashed line, it may only be above the northern horizon briefly. To see all the sky, as depicted in the North maps, you would need to be at a latitude similar to Darwin.

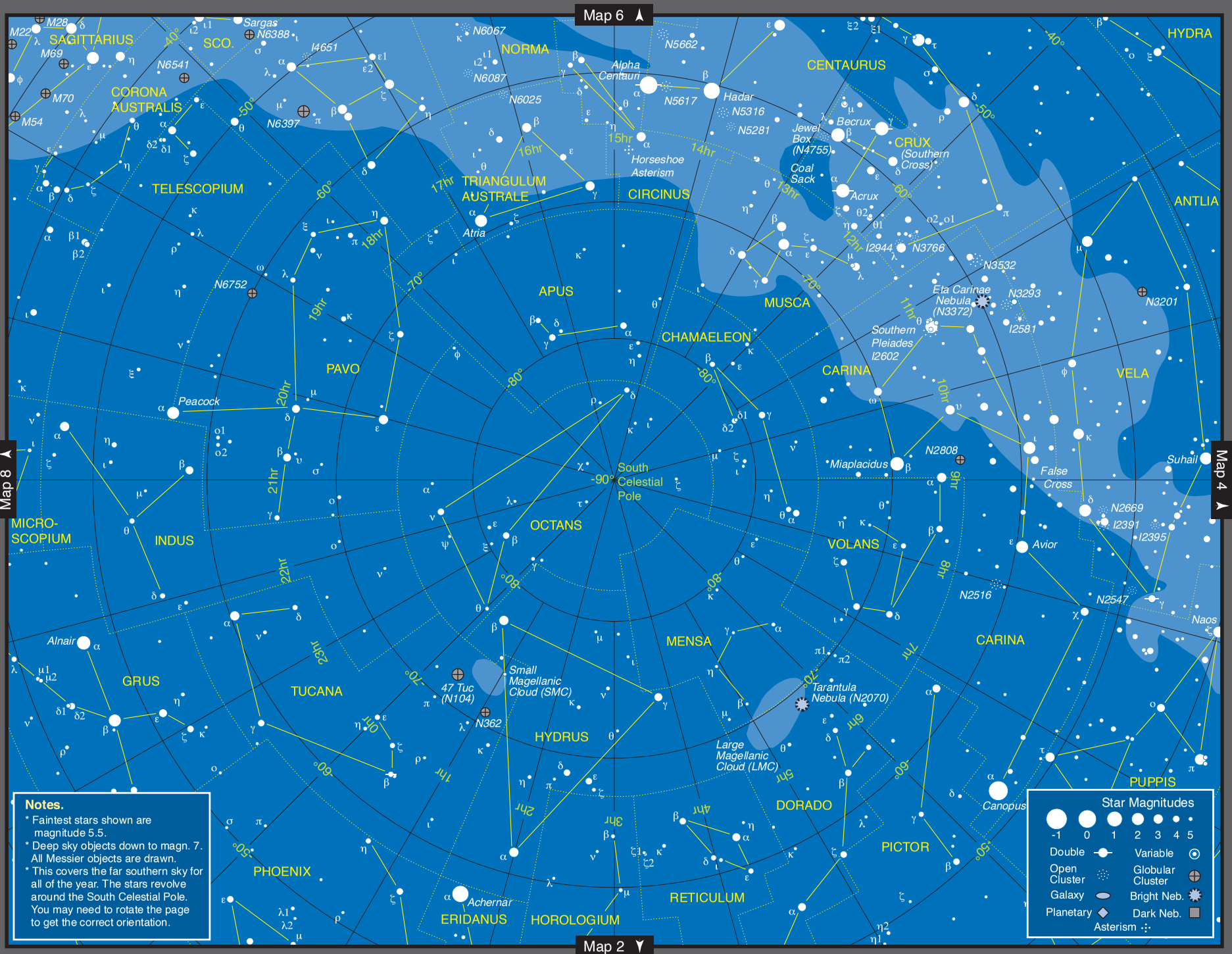
What are the planet lines?

Lines are shown to indicate the approximate path in the sky for **Mars**, **Jupiter, Saturn, Uranus, Neptune and Pluto** for the year. With the exception of Mars, you can then go to the relevant finder chart. The path for **Mars** has the position marked for each month and thus replaces a separate finder chart. The Moon, Mercury and Venus are not shown. The Sky View diagrams (see Part I) show the location and optimum time to observe these objects.

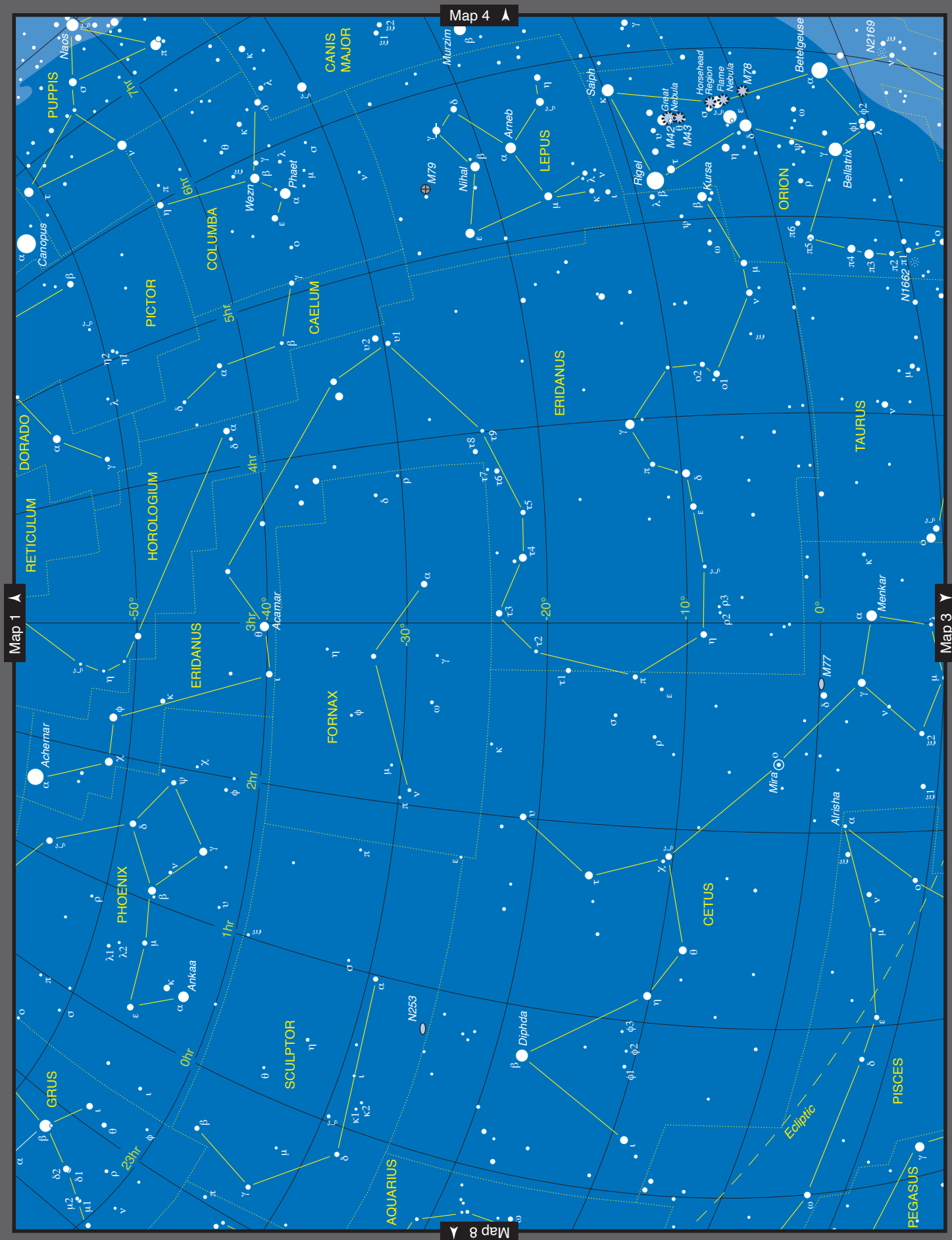
What else is shown on the maps?

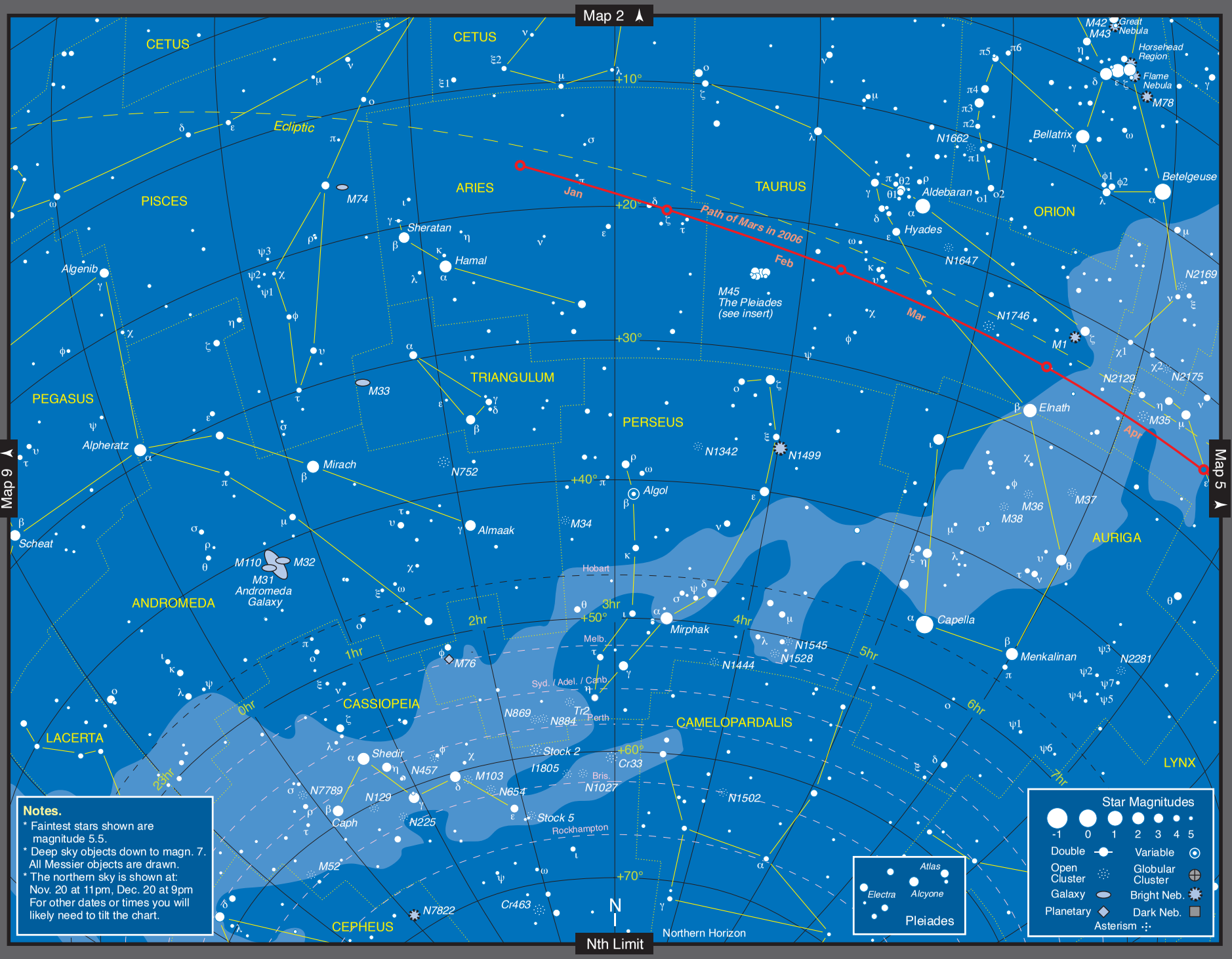
- **Deep sky objects** down to magnitude 7 and all of the Messier objects (see the legend). Most of these objects are identified by their common names, Messier number (M), NGC (N) or IC (I) catalogue numbers. Most of the star clusters should be visible through a pair of binoculars. The galaxies, planetary and diffuse nebulae may need a small telescope.
- **Constellation lines**. The yellow dotted lines are the boundaries and the solid yellow lines join some of the brighter stars to help in recognising the constellation's pattern. This pattern has been kept the same as that used in the Sky Views.
- A few of the brighter **Double Stars and Variables**.
- A light blue shading shows the **Milky Way and Magellanic Clouds**.

Pipe Nebula in Ophiuchus *This rather distinctive dark nebula (near centre) is approximately 7 degrees long and its 'smoke' can be seen trailing off towards Antares on the centre right hand edge of the image. Can you see the 'Prancing Horse' dark nebula? 'The Pipe' can fit neatly into the field of a low power pair of binoculars, although if the sky is dark enough it is clearly visible with the naked-eye, along with the numerous other dark lanes that cross the central galactic bulge of the Milky Way. The bright 'star' above Antares is Saturn in March 1986. Photograph is a 6 minute guided image using Kodak Tri X in a 35mm camera (55mm lens) mounted piggy-back on an equatorially tracking telescope.*


Map 6
Map 8
Map 4
Map 2
SAGITTARIUS
SCO.
CORONA AUSTRALIS
TELESCOPIUM
NORMA
TRIANGULUM AUSTRALE
CIRCINUS
CENTAURUS
HYDRA
CRUX (Southern Cross)
ANTLIA
APUS
MUSCA
CHAMAELEON
CARINA
VELA
PAVO
Peacock
INDUS
MICRO-SCOPIUM
OCTANS
South Celestial Pole
VOLANS
Miaplacidus
False Cross
Suhail
Avior
Naos
MENSA
CARINA
GRUS
Alnair
TUCANA
Small Magellanic Cloud (SMC)
47 Tuc (N104)
Tarantula Nebula (N2070)
HYDRUS
Large Magellanic Cloud (LMC)
DORADO
PUPPIS
Canopus
PICTOR
PHOENIX
Achernar
ERIDANUS
RETICULUM
HOROLOGIUM
Alpha Centauri
Hadar
Horseshoe Asterism
Jewel Box (N4755)
Becrux
Coal Sack
Acrux
Atria
Eta Carinae Nebula (N3372)
Southern Pleiades
I2602
N3293
I2581
N3201
N3532
N3766
I2944
N2808
N2669
I2391
I2395
N2516
N2547
N6752
N6541
N6388
Sargas
I4651
N6067
N6087
N6025
N6397
N5662
N5617
N5316
N5281
M28
M22
M69
M70
M54
Map 1 - Looking South
Notes.
* Faintest stars shown are magnitude 5.5.
* Deep sky objects down to magn. 7. All Messier objects are drawn.
* This covers the far southern sky for all of the year. The stars revolve around the South Celestial Pole. You may need to rotate the page to get the correct orientation.
Star Magnitudes
-1 0 1 2 3 4 5
Double
Variable
Open Cluster
Globular Cluster
Galaxy
Bright Neb.
Planetary
Dark Neb.
Asterism

Map 2 - Summer (Centre)



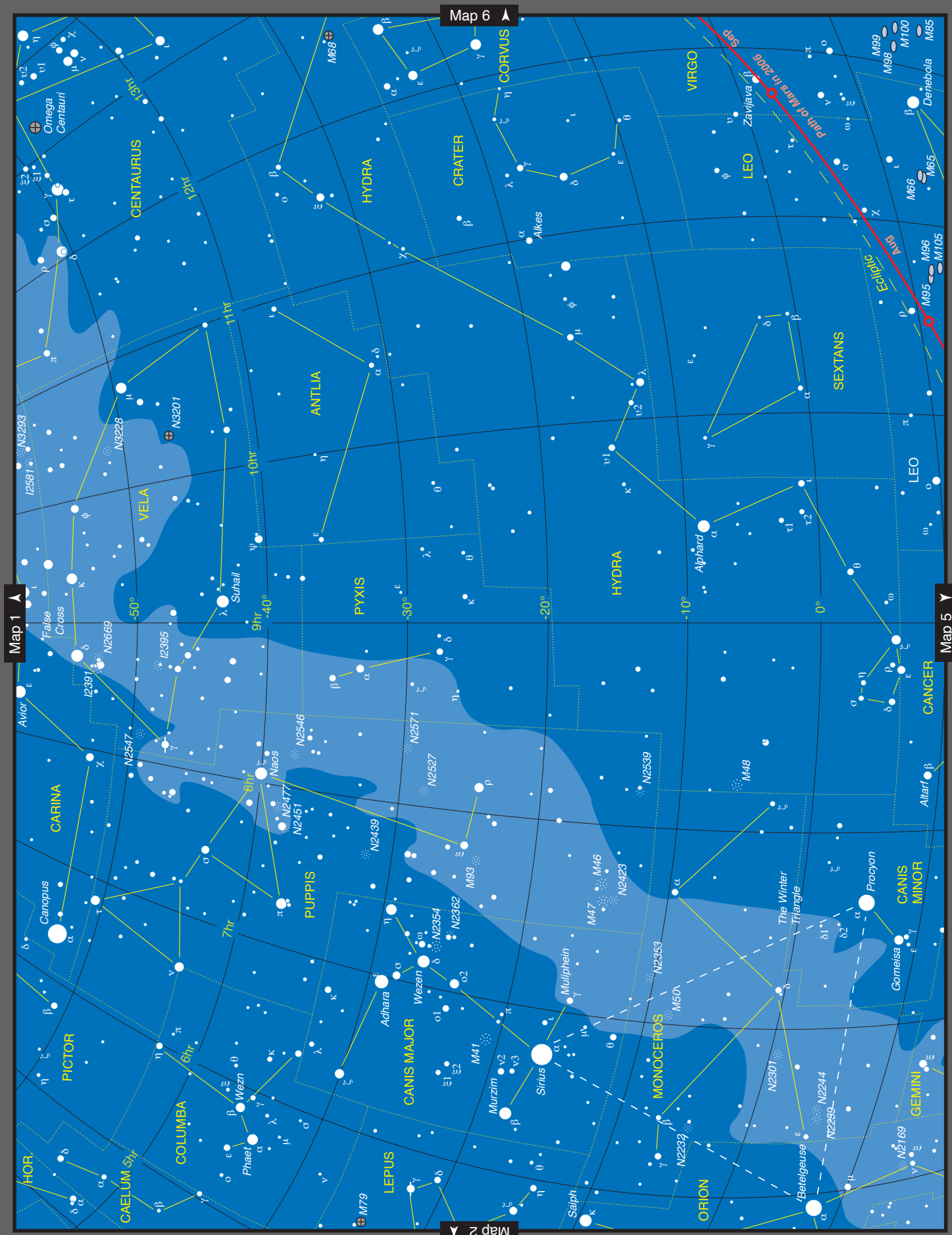


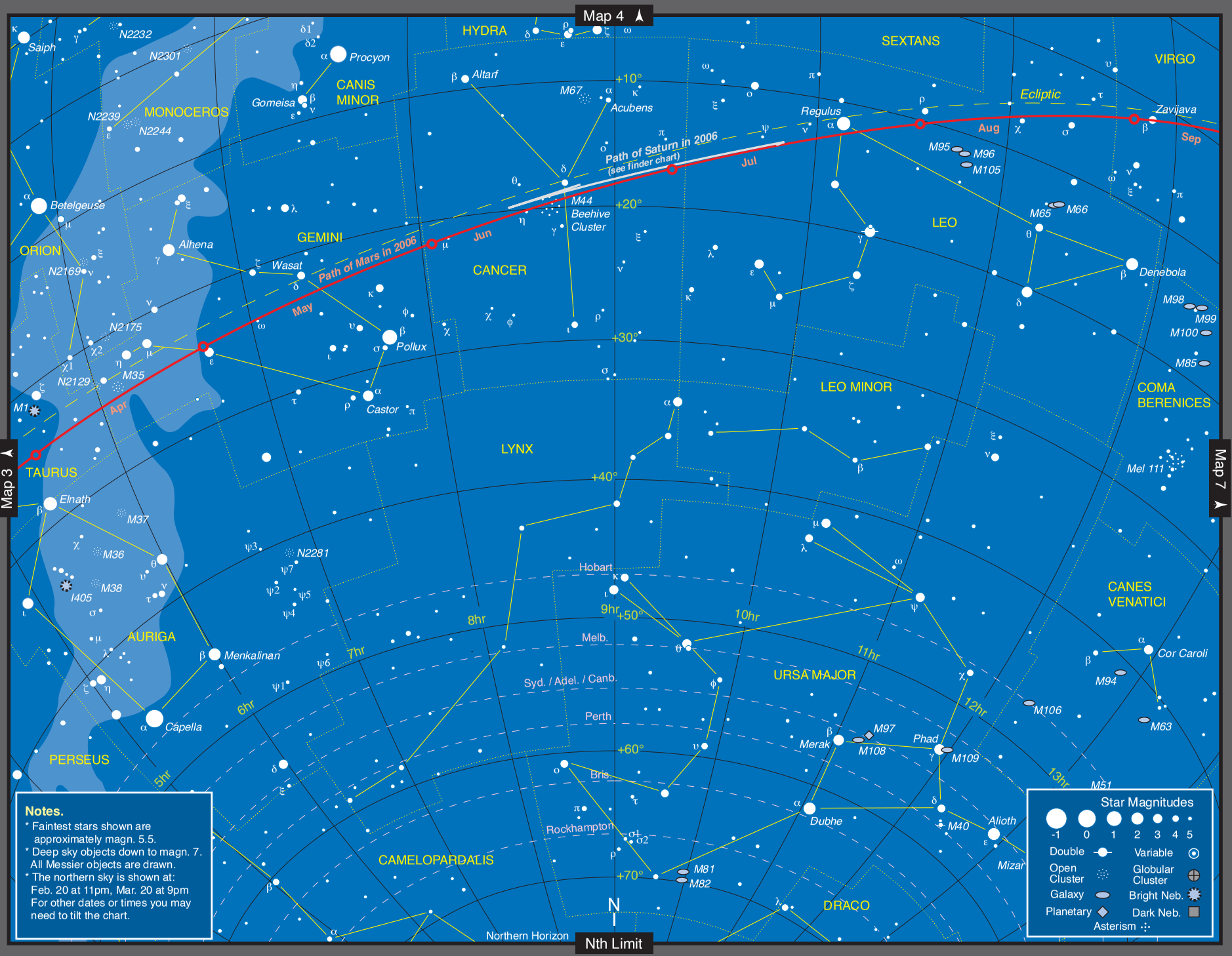
Notes.

* Faintest stars shown are magnitude 5.5.
* Deep sky objects down to magn. 7. All Messier objects are drawn.
* The northern sky is shown at: Nov. 20 at 11pm, Dec. 20 at 9pm For other dates or times you will likely need to tilt the chart.

Map 3 - Summer (North)

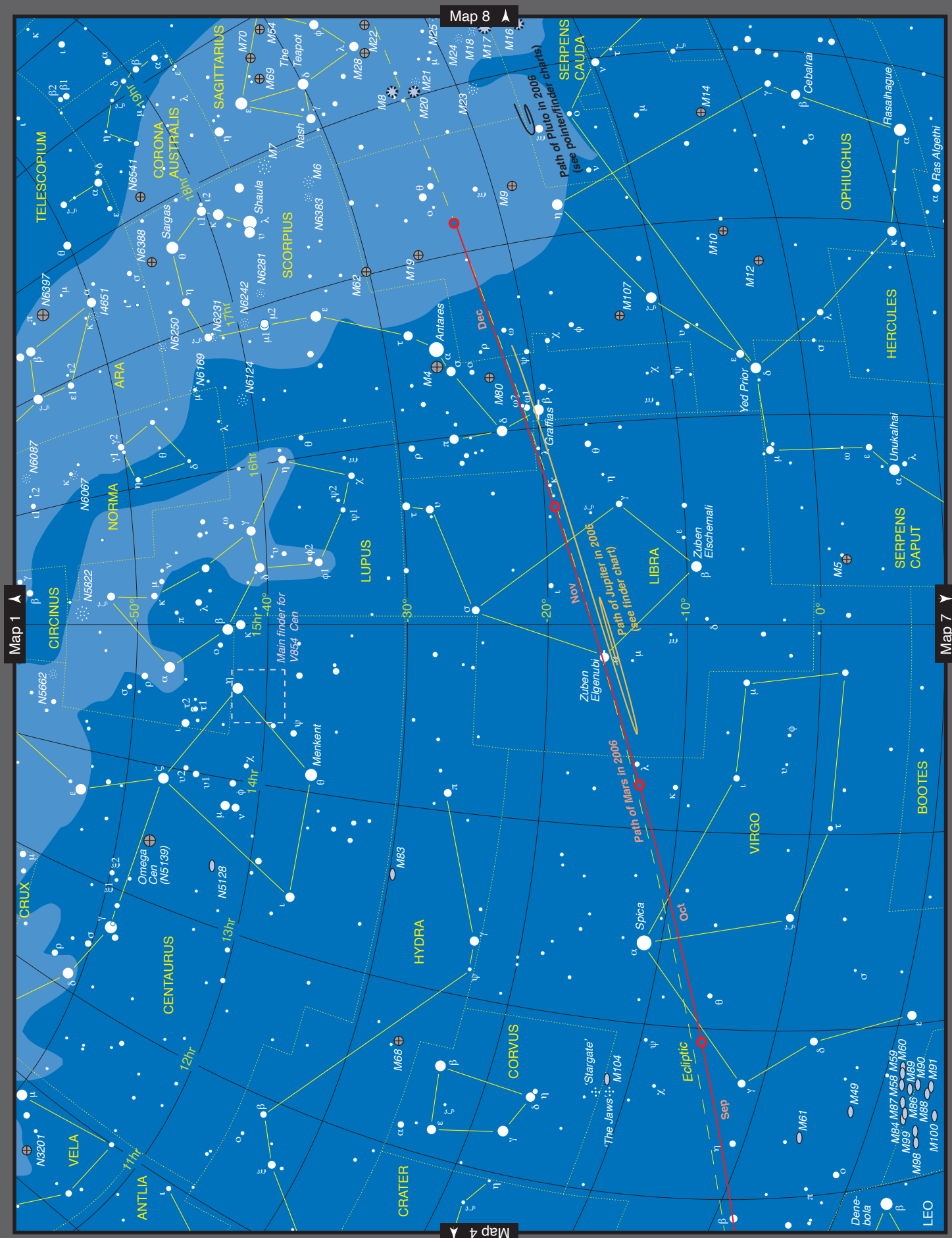
Map 4 - Autumn (Centre)

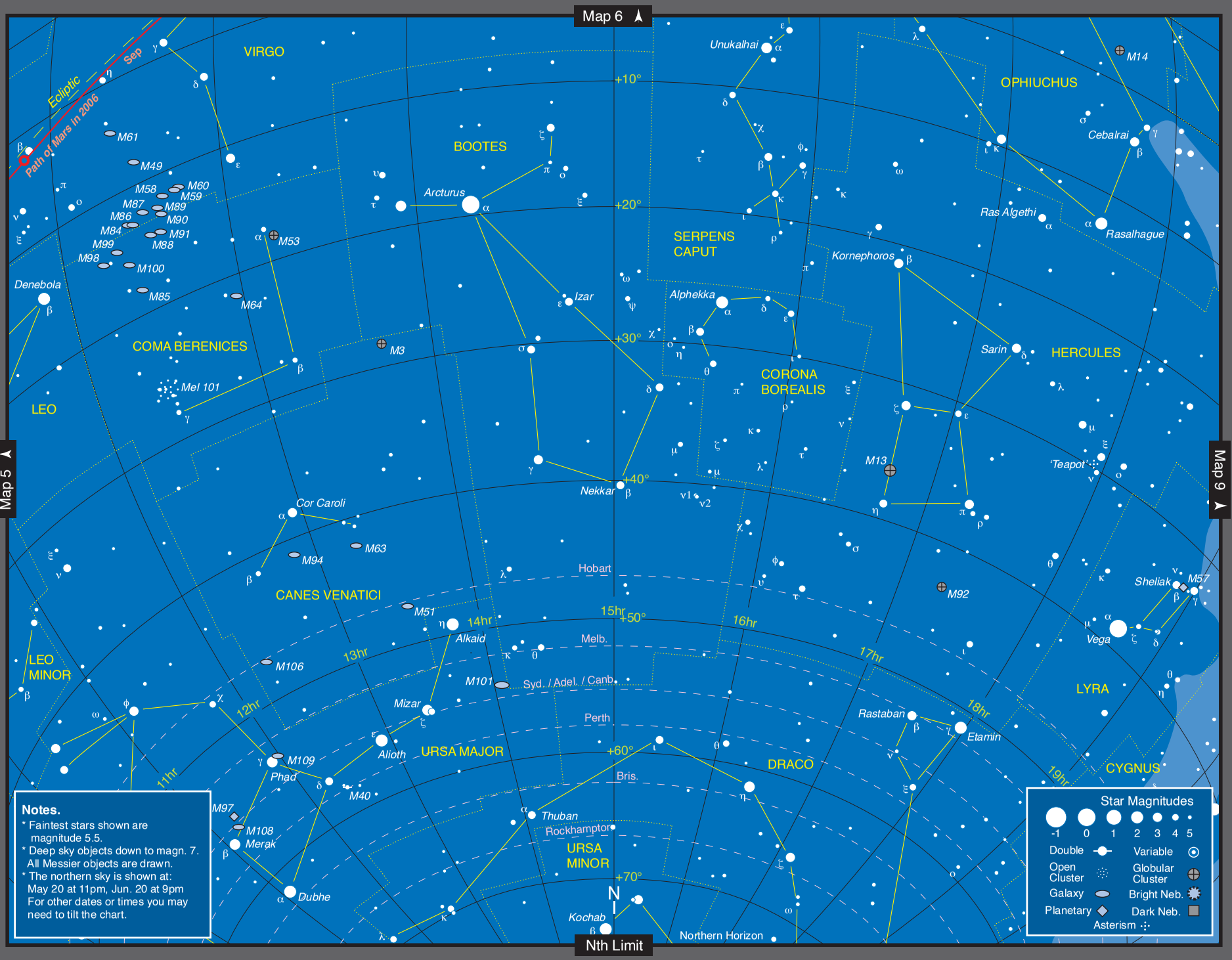




Map 5 - Autumn (North)

Map 6 - Winter (Centre)





Notes.

* Faintest stars shown are magnitude 5.5.
* Deep sky objects down to magn. 7. All Messier objects are drawn.
* The northern sky is shown at: May 20 at 11pm, Jun. 20 at 9pm For other dates or times you may need to tilt the chart.

Star Magnitudes

-1 0 1 2 3 4 5

Double — Variable

Open Cluster — Globular Cluster

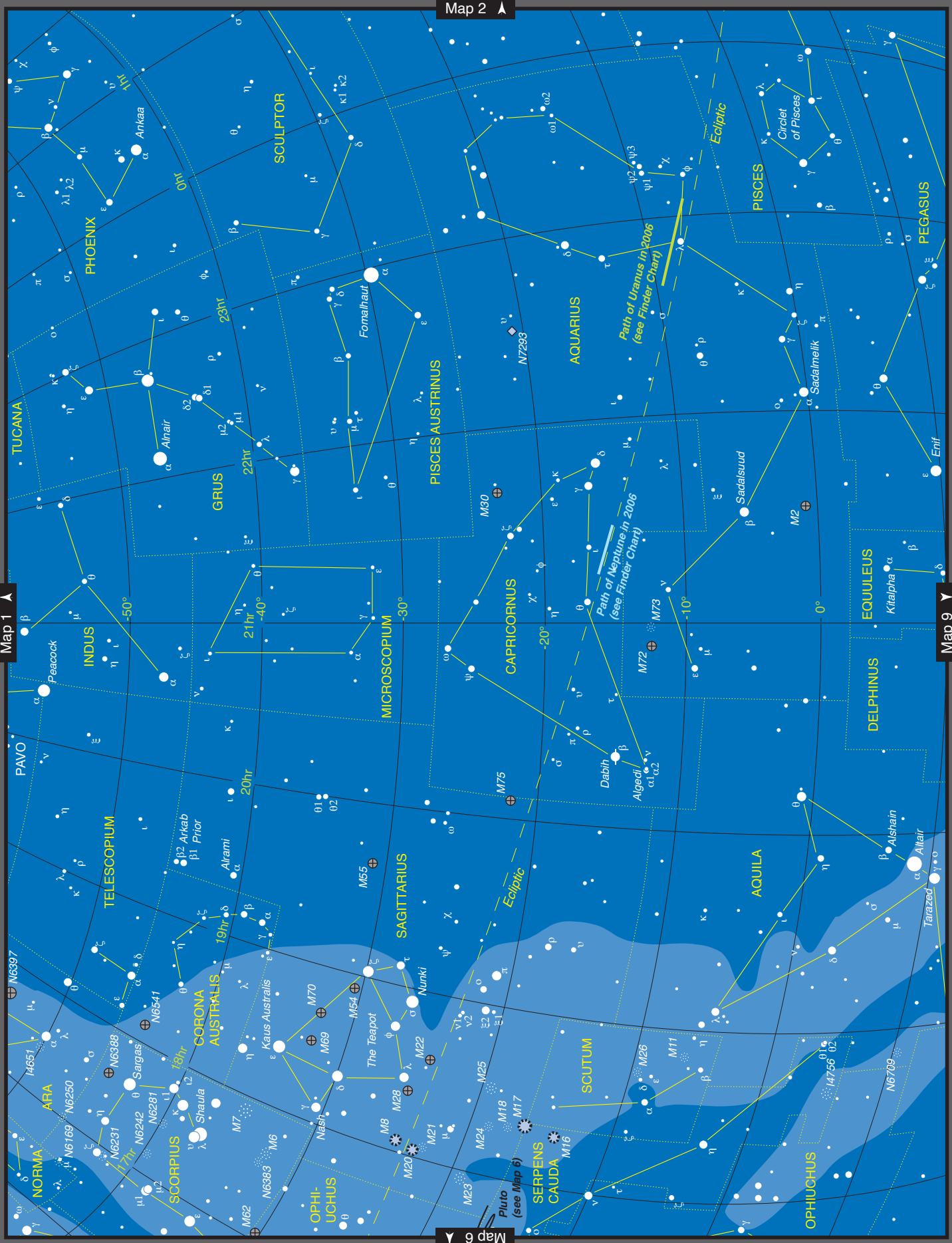
Galaxy — Bright Neb.

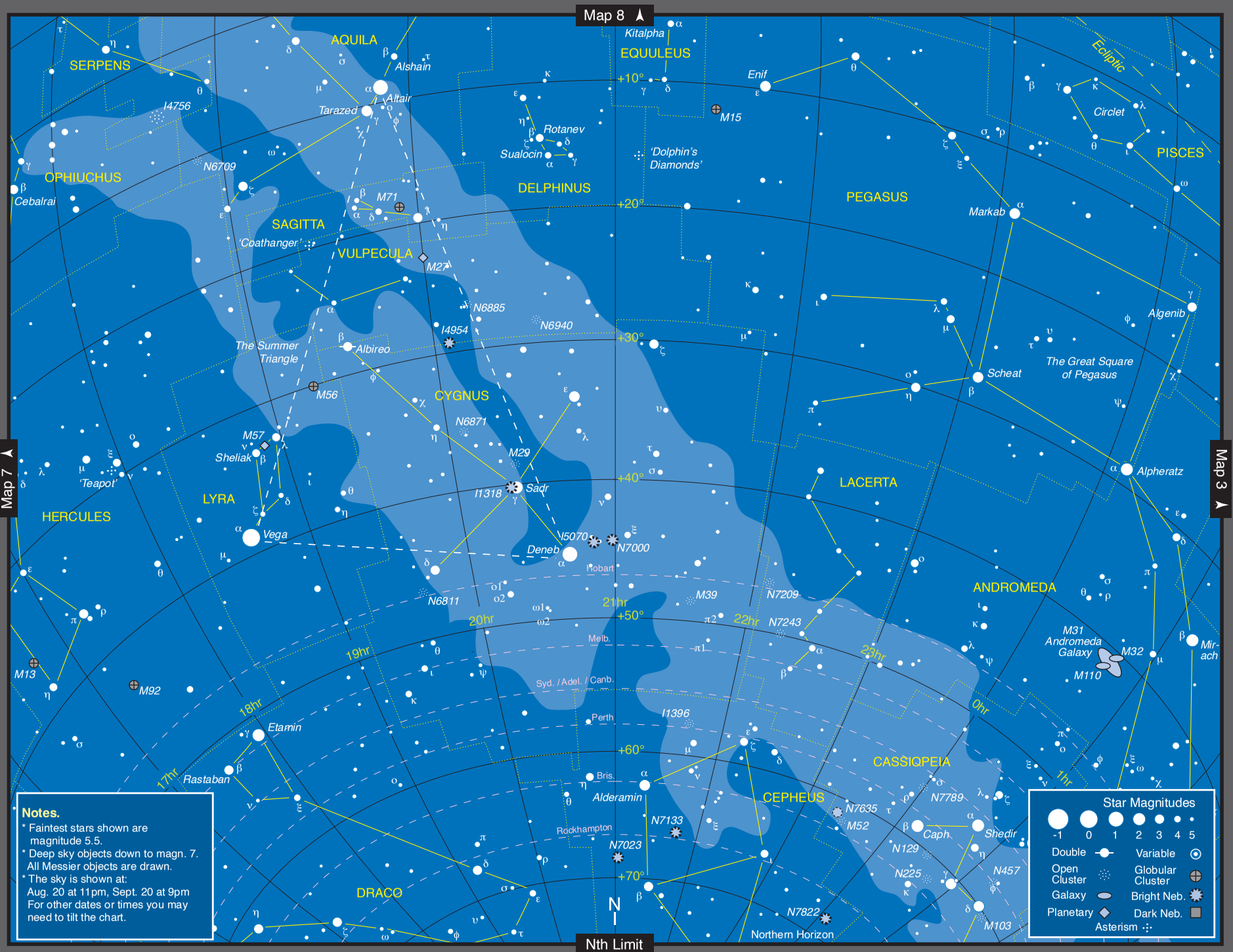
Planetary — Dark Neb.

Asterism

Map 7 - Winter (North)

Map 8 - Spring (Centre)





Map 9 - Spring (North)

PART II THE SOLAR SYSTEM

This introduction is only brief, as many of the specific explanations are located in the relevant sections.

Time. There are four zones used in Part II. They are: Eastern Standard Time (EST), Central Standard Time (CST), Western Standard Time (WST) and Universal Time (UT).

Time Zones. The local Australian standard zones are used where ever they involve location specific data, such as rise and set times of the Sun, Moon and planets and lunar occultation tables. As in Part I, no allowance has been made for Daylight Saving Time. When in force you need to add one hour to the times given here. Information related to Jupiter's moons (pp. 111 – 113) is given in EST and WST.

Universal Time, or UT, is the mean time for the meridian of Greenwich, England, reckoned from midnight. EST is 10 hours ahead of UT, CST is 9.5 hours ahead and WST is 8 hours ahead. For example, midnight UT, or 0 hr, is equal to 10:00hr (10:00am) EST, 9:30hr (9:30am) CST and 8:00hr (8:00am) WST.

The 24 hr clock is often used in astronomy e.g., 16:00 hr is the same as 4:00 pm. This avoids having to distinguish between 'am' and 'pm'. The 24hr approach is frequently used in Part II of this book e.g., for rise/set times.

The satellite data for Saturn, Uranus and Neptune use decimal days. There are worked examples on these pages to further explain this.

Locations. Rise and set times and lunar occultation data are given for specific cities. The latitudes and longitudes used are:

Adelaide	34° 54' S	138° 36' E	Brisbane	27° 30' S	153° 01' E
Canberra	35° 15' S	149° 08' E	Darwin	12° 23' S	130° 44' E
Hobart	42° 48' S	147° 13' E	Melbourne	37° 50' S	145° 00' E
Perth	31° 57' S	115° 51' E	Sydney	33° 54' S	151° 15' E

Astronomical Co-ordinates or Positions. The astronomical positions are given in equatorial co-ordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude on Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one-hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations, those south have negative (–). The Right Ascension and Declination grid has been marked on the All Sky Maps (see previous pages). The RA has a line for each hour and the Declination has a line every 10°.

The Earth's daily rotation on its polar axis causes the stars to appear to rotate around a point in the sky. From southern latitudes, including Australia, this point is called the South Celestial Pole and is at declination –90° (see Map 1 in the All Sky Maps). The North Celestial Pole, not visible from the Southern Hemisphere, is at +90°. The celestial equator and poles can be described as projections on the sky of their terrestrial counterparts.

Position Tables. Right Ascension and Declination have been calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. This means they have been calculated for a position at the centre of the Earth. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Except for the Moon, this slight shift is insignificant. Positions for the outer planets are given in weekly intervals and correspond to Saturdays; those for the Sun, Moon, Venus and Mercury are daily.

Rise and Set Times. Those given are when the upper limb of the object is coincident with the theoretical horizon. The times are adjusted for atmospheric refraction. The intervals used for rise/sets are weekly, the dates corresponding to Saturdays. The exception is the Moon, which is presented for each day. Also see note on time zones (above).

Use of Star Atlases. As the Earth orbits the Sun, the polar axis remains fixed relative to the stars. The points, around which the stars appear to rotate (the celestial poles), appear to never change no matter what time of the year one is observing. However, the positions of the celestial poles do slowly move against the star field. This is called precession and is caused by the Earth's axis slowly wobbling, like a spinning top, over thousands of years. 'Epoch 2000.0' refers to an object's position relative to where the celestial poles (+ /-90° in declination) were in the year 2000. The All Sky Maps are Epoch 2000.0.

Field of View in a Telescope. All the satellite diagrams and finder charts in this book are drawn to correct or normal sky orientation, i.e., east to the left, and north to the top (in the sky, east and west are opposite to what is seen on terrestrial maps). Telescope systems that use an odd number of mirrors will reverse the image. The common use of star diagonals in Schmidt-Cassegrains or traditional refractors causes this reversal. Binoculars or straight Newtonians show 'normal' sky images (the Newtonian image will be upside down).

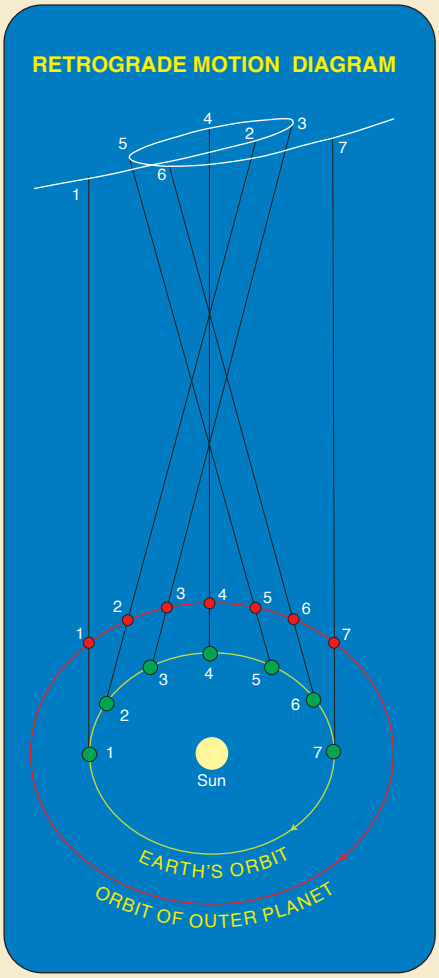
Finder Charts. No finder charts are presented for the Moon, Mercury, Venus or Mars. Their rapid motion during the year causes them to cover a very large section of the sky which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams (see Part I) should be sufficient to act as finders. With regard to Mars it was decided that the All Sky Maps gave adequate detail to easily find the red planet, so its traditional finder has been included on the All Sky Maps. Although there are separate finder charts for Jupiter, Saturn, Uranus, Neptune and Pluto, the approximate track for each is also shown on the All Sky Maps. This acts as a pointer to help you find the much narrower field finders.

RETROGRADE MOTION

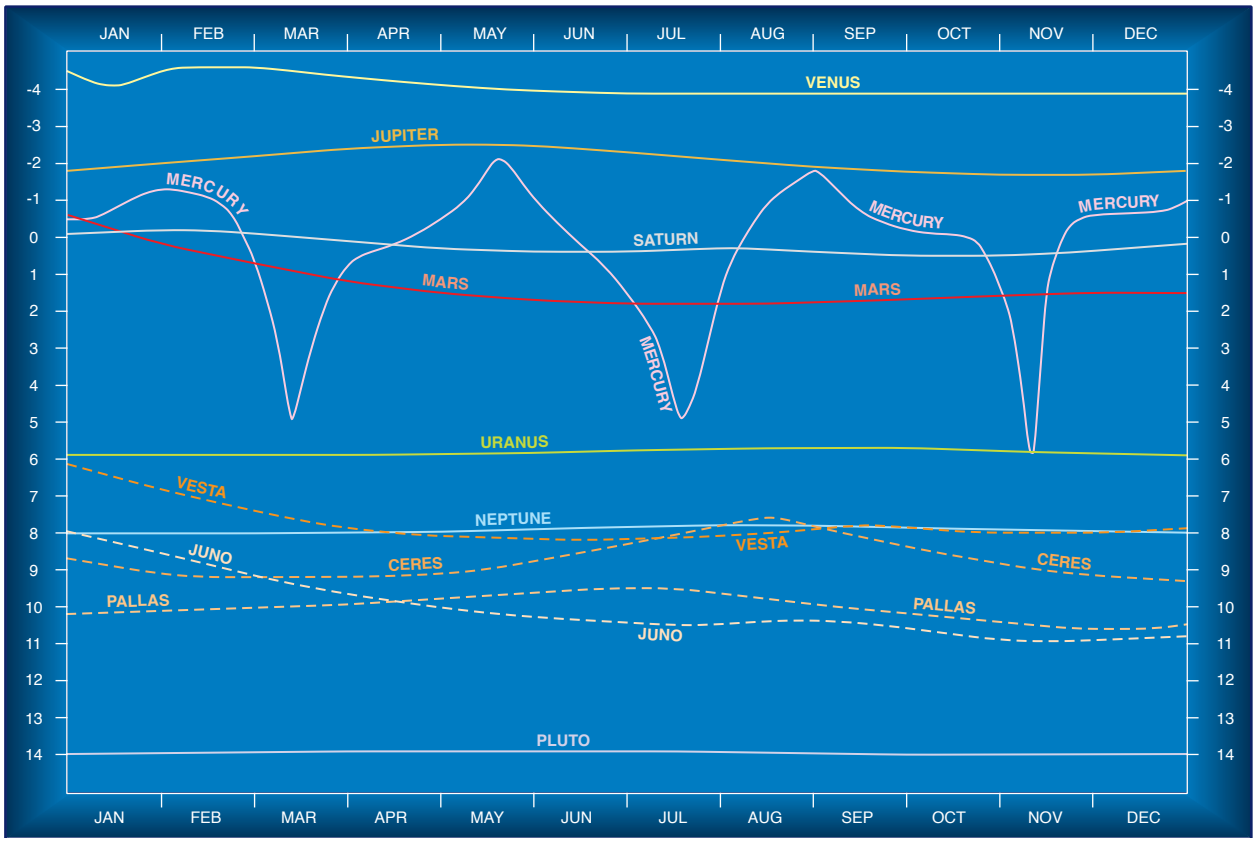
The finder charts for the outer planets have one thing in common — an apparent motion with a loop or 'S' shape. This only applies to the period during opposition. See the All Sky Charts or the Finder Charts for examples. The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

In the diagram, the shaded area represents the path of an outer planet against the celestial sphere viewed from the south (below the ecliptic). As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet appears to move from east to west, instead of west to east. At positions 1 and 2, Uranus continues its west to east path and begins to slow to position 3 as the Earth catches up. Between 3 and 5, Uranus is in retrograde motion (i.e., moving east to west) and it is at opposition (in line with the Earth and the Sun) at 4. At points 3 and 5, the planet is said to be stationary. After 5, as the Earth passes the slower planet, Uranus continues its west to east direction.

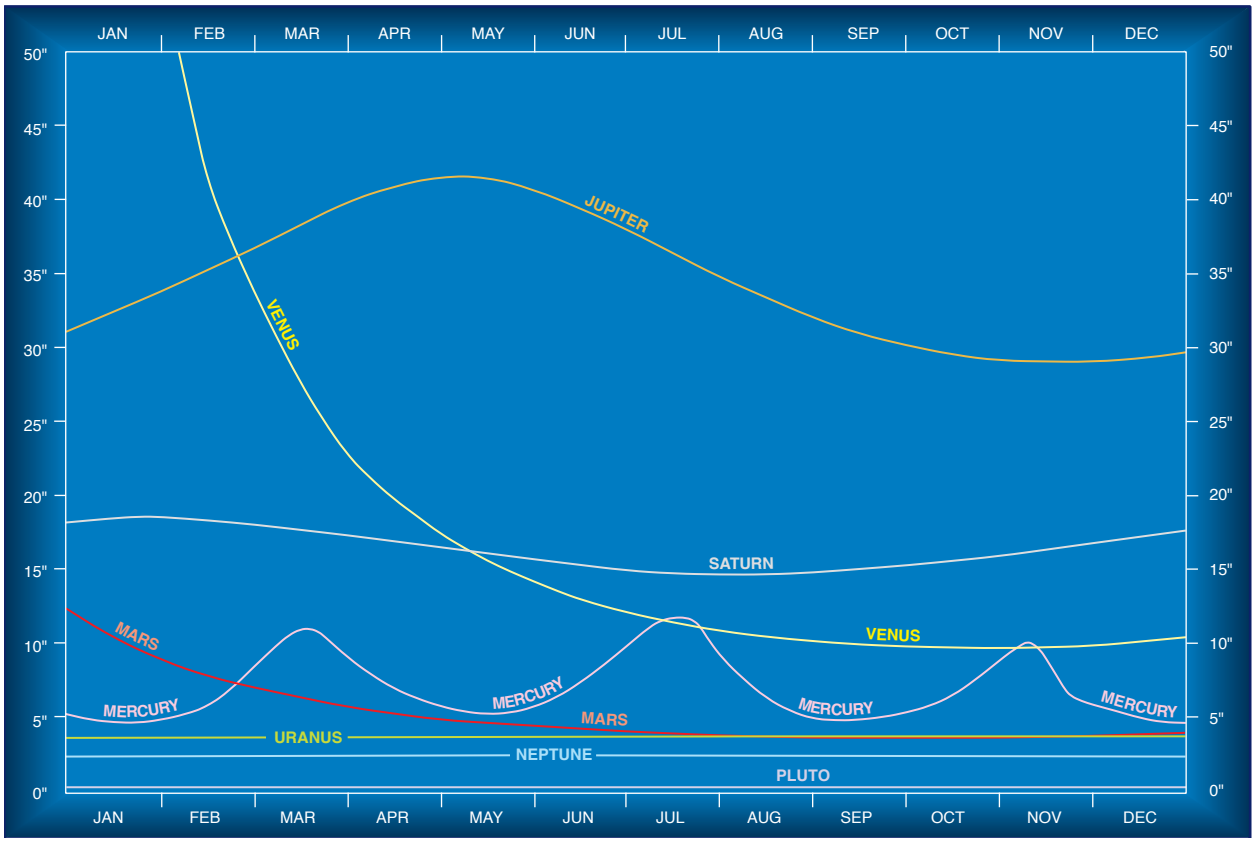
Because the orbits of the outer planets are inclined to that of the Earth's, the path can never be a straight line. It will always be a loop or an S-bend.



MAGNITUDES of the PLANETS and MAJOR ASTEROIDS



PLANETARY ANGULAR SIZE



GEOCENTRIC PHENOMENA (UT)

Planet	Superior Conjunction	Greatest Elongation East	Stationary	Inferior Conjunction	Stationary	Greatest Elongation West
Mercury	26 Jan, 22h	24 Feb, 5h	2 Mar, 7h	12 Mar, 3h	24 Mar, 12h	8 Apr, 19h
	18 May, 20h	20 Jun, 20h	4 Jul, 2h	18 Jul, 7h	28 Jul, 17h	7 Aug, 1h
	1 Sep, 5h	17 Oct, 4h	29 Oct, 0h	8 Nov, 22h	17 Nov, 19h	25 Nov, 13h
Venus	27 Oct, 18h			14 Jan, 0h	3 Feb, 7h	25 Mar, 7h

Planet	Conjunction	Stationary	Opposition	Stationary	EARTH	
Mars	23 Oct, 7h	-	-	-	Perihelion	4 Jan, 15h
Jupiter	21 Nov, 23h	5 Mar, 0h	4 May, 15h	6 Jul, 19h	Equinox	20 Mar, 18h
Saturn	7 Aug, 12h	6 Dec, 20h	27 Jan, 23h	5 Apr, 12h	Solstice	21 Jun, 12h
Uranus	1 Mar, 11h	19 Jun, 16h	5 Sep, 11h	20 Nov, 14h	Aphelion	3 Jul, 23h
Neptune	6 Feb, 6h	22 May, 17h	11 Aug, 5h	29 Oct, 7h	Equinox	23 Sep, 4h
Pluto	18 Dec, 15h	29 Mar, 15h	16 Jun, 17h	5 Sep, 11h	Solstice	22 Dec, 0h

HELIOCENTRIC PHENOMENA (UT)

Planet	Aphelion	Greatest Latitude South	Ascending Node	Perihelion	Greatest Latitude North	Descending Node
Mercury	10 Jan	30 Jan	18 Feb	22 Feb	5 Mar	28 Mar
	7 Apr	28 Apr	17 May	21 May	1 Jun	24 Jun
	4 Jul	25 Jul	13 Aug	17 Aug	28 Aug	20 Sep
	30 Sep	21 Oct	9 Nov	13 Nov	24 Nov	17 Dec
	27 Dec	-	-	-	-	-
Venus	-	-		24 Jan	15 Feb	12 Apr
	17 May	8 Jun	3 Aug	6 Sep	28 Sep	23 Nov
Mars	26 Jun	-	-	-	19 May	3 Dec

Jupiter, Saturn, Uranus, Neptune and Pluto have no events in 2006

SOLAR SYSTEM DATA – SUN, MOON AND THE PLANETS

NAME	MEAN DISTANCE FROM SUN ($\times 10^3$ km)	(Earth = 1)	MAG at OPP	EQUATORIAL DIAMETER (km).	FLATTENING [1]	No of MOONS	MASS ($\times 10^{24}$ kg)	(Earth = 1)
Sun	-		-26.8	1392530	0	-	1989085	332946
Moon	-		-12.74 [11]	3475	0	-	0.073483	0.0123
Mercury	57856	0.387	0.16 [12]	4879	0	0	0.33022	0.055
Venus	108132	0.723	-4.07 [12]	12104	0	0	4.8690	0.816
Earth	149492	1.000	-3.5 [13]	12756	0.00335364	1	5.9742	1.000
Mars	227780	1.524	-2.01	6794	0.006476	2	0.64191	0.107
Jupiter	777776	5.203	-2.70	142984	0.064874	63	1898.8	317.900
Saturn	1425983	9.540	0.67	120536	0.097962	47	568.50	95.200
Uranus	2867760	19.180	5.52	51118	0.022927	27	86.625	14.500
Neptune	4492800	30.700	7.84	49528	0.017081	13	102.78	17.400
Pluto	5745000	39.670	13.7	2302	0	1	0.015	0.003

NAME	VOLUME (Earth = 1)	SIDEREAL PERIOD [2]	SYNODIC PERIOD (days) [3]	AXIAL ROTATION (days) [4]	ALBEDO [5]	ECCEN-TRICITY [6]	INCLINATION [7]	OBLIQUITY [8]
Sun	1300000	-	-	25.38 [9]	-	-	-	7° 15' [10]
Moon	0.02	27.32 d	29.4	27.32166	0.12	0.0549	5° 08' 40"	6° 41'
Mercury	0.06	87.97 d	115.8	58.6462	0.106	0.20562	7° 00' 00"	0° 00'
Venus	0.86	224.7 d	583.9	-243.0187	0.65	0.00681	3° 23' 38"	92° 00'
Earth	1	365.256 d	-	0.99726968	0.367	0.01681	0° 00' 00"	23° 26'
Mars	0.15	687 d	779.8	1.02595675	0.150	0.09333	1° 51' 01"	25° 10'
Jupiter	1323	11.86 y	398.8	0.41354 [14]	0.52	0.04837	1° 18' 28"	3° 07'
Saturn	752	29.46 y	378.0	0.44401 [14]	0.47	0.05582	2° 29' 29"	26° 45'
Uranus	64	84.01 y	369.7	-0.71833	0.51	0.0471	0° 46' 22"	98° 00'
Neptune	54	164.8 y	367.5	0.67125	0.41	0.00855	1° 46' 38"	29° 00'
Pluto	0.007	249.9 y	366.7	-6.3872	0.30	0.2486	17° 09' 00"	118° 00'

Notes:

1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the north pole.
5 The ratio of the sunlight reflected to that received.
6 The measure of how long or thin the ellipse of the planet's orbit is.
7 The angle of the planet's orbit from the plane of the ecliptic.
8 The degree of inclination of the planet's equator to its orbit
9 Equatorial region (the polar areas of the Sun rotate in a period of 29 to 30 days).
10 To the ecliptic.
11 From the Earth.
12 At mean greatest elongation.
13 As seen from the Sun.
14 Based on System III rotation. Similar to systems I or II except a radio source within the planet is used as the reference point.

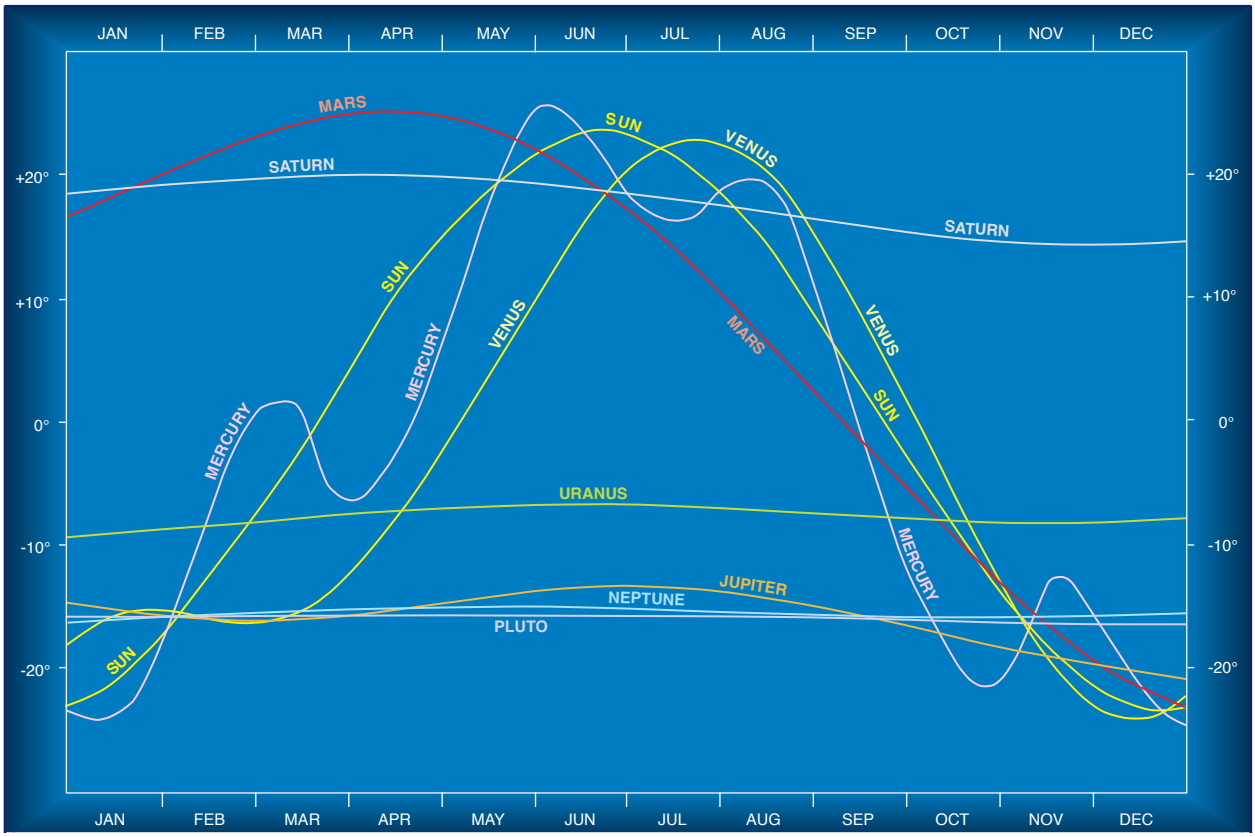
SOLAR SYSTEM DATA — SATELLITES

PLANET	SATELLITE	ORBITAL PERIOD (days)	MAX. ELONG AT MEAN OPPOSITION	SEMIMAJOR AXIS (x10³ km)	DIAMETER (km)	MAGNITUDE AT OPPOSITION
Earth	Moon	27.321661		384.400	3,475	-12.74
Mars	Phobos	0.31891023	25"	9.378	26.8x21x18.4	11.3
	Deimos	1.2624407	1' 02"	23.459	15.0x12x10.4	12.40
Jupiter	Metis	0.30	0' 42"	128	43	17.5
	Adrastea	0.30	0' 42"	129	16	18.7
	Amalthea	0.50	0' 59"	181	167	14.1
	Thebe	0.68	1' 13"	222	99	16.0
	Io	1.77	2' 18"	422	3,643	5.1
	Europa	3.55	3' 40"	671	3,122	5.3
	Ganymede	7.16	5' 51"	1,070	5,262	4.6
	Callisto	16.69	10' 18"	1,883	4,821	5.7
	Themisto	130.02		7,507	8	21.0
	Leda	240.92	1° 00' 39"	11,094	20	19.5
	Himalia	250.56	1° 02' 46"	11,480	170	14.6
	Lysithea	259.20	1° 04' 04"	11,720	36	18.3
	Elara	259.64	1° 04' 10"	11,737	86	16.3
	S/2000 J 11	286.95		12,555	4	22.4R
	Carpo	456.1		16,989	3	23.0R
	S/2003 J 3	490.45		17,929	2	23.4R
	S/2003 J 18	511.75		18,445	2	23.4R
	S/2003 J 12	536.23		19,028	1	23.9R
	S/2003 J 4	547.50		19,294	2	23.0R
	Euporie	550.67		19,302	2	23.1R
	S/2003 J 16	598.04		20,464	2	23.3R
	Orthosie	622.58		20,721	2	23.1R
	Euanthe	620.55		20,799	3	22.8R
	Thyone	627.26		20,940	4	22.3R
	Mneme	620.0		21,069	2	23.3R
	S/2003 J 10	625.16		21,078	2	23.6R
	Harpalyke	623.34		21,105	4	22.2
	Hermippe	633.91		21,131	4	22.1R
	Praxidike	625.30		21,147	7	21.2
	Thelxinoe	628.1		21,162	2	23.5R
	Ananke	629.77	1° 55' 52"	21,200	28	18.8
	Helike	634.8		21,263	4	22.6R
	Iocaste	631.49		21,269	5	21.8
	S/2003 J 15	678.19		22,253	2	23.5R
	Carme	734.17	2° 03' 31"	22,600	46	17.6
	Eurydome	717.31		22,865	3	22.7R
	S/2003 J 17	708.81		22,918	2	23.4R
	Arche	723.90		22,931	3	22.8R
	S/2003 J 9	713.51		23,020	1	23.7R
	Autonoe	762.70		23,039	4	22.0R
	Pasithee	719.48		23,096	2	23.2R
	Chaldene	723.78		23,179	4	22.5
	Isonoe	725.52		23,217	4	22.5
	Kale	729.47		23,217	2	23.0R
	Aitne	730.22		23,231	3	22.7R
	Erinome	728.26		23,279	3	22.8
	S/2003 J 19	728.84		23,348	2	23.7R
	Taygete	732.24		23,360	5	21.9
	Sponde	748.33		23,487	2	23.0R
	Pasiphae	743.63	2° 08' 26"	23,500	60	17.0
	Kalyke	742.98		23,583	5	21.8
	Eukelade	746.4		23,661	4	22.6R
	Sinope	758.90	2° 09' 31"	23,700	38	18.1
	Megaclite	752.82		23,806	5	21.7
	Hegemone	739.6		23,947	3	22.8R
	Aoede	761.5		23,981	4	22.5R
	S/2003 J 14	761.45		24,039	2	23.6R
	Kallichore	764.7		24,043	2	23.7R
	S/2003 J 23	759.7		24,056	2	23.6R
	Callirrhoe	758.77		24,102	9	20.7
	Cyllene	737.8		24,349	2	23.2R
	S/2003 J 5	781.03		24,450	4	22.4R
	S/2003 J 2	889.20		26,658	2	23.2R
Saturn	Pan	0.58	0' 21"	134	20	19.4
	S/2005 S 1	0.594		137	7	
	Atlas	0.60	0' 22"	138	32	19.0
	Prometheus	0.61	0' 23"	139	100	15.8
	Pandora	0.63	0' 23"	142	84	16.4
	Epimetheus	0.69	0' 24"	151	119	15.6
	Janus	0.70	0' 24"	152	178	14.4
	Mimas	0.94	0' 30"	186	397	12.8
	Methone	1.01		194	3	23
	Pallene	1.14		211	4	23
	Enceladus	1.37	0' 38"	238	499	11.8
Saturn	Calypso	1.89	0' 48"	295	19	18.7
	Telesto	1.89	0' 48"	295	24	18.5
	Tethys	1.89	0' 48"	295	1,060	10.2
	Dione	2.74	1' 01"	377	1,118	10.4
	Helene	2.74	1' 01"	377	32	18.4
	Polydeuces	2.74		377	4	
	Rhea	4.52	1' 25"	527	1,528	9.6
	Titan	15.95	3' 17"	1,222	5,150	8.4
	Hyperion	21.28	3' 59"	1,464	266	14.4
	Iapetus	79.33	9' 35"	3,561	1,436	11.0
	Kiviuq	449.22		11,365	14	22.0R
	Ijiraq	451.47		11,442	10	22.6R
	Phoebe	548.21	34' 51"	12,944	220	16.4
	Paaliaq	686.94		15,198	19	21.3R
	Skathi	728.9		15,647	6	23.6R
	Albiorix	783.47		16,394	26	20.5R
	S/2004 S 11	822		16,950	6	24.1R
	Erriapo	871.25		17,604	9	23.0R
	Siarnaq	895.55		18,195	32	20.1R
	Tarvos	926.13		18,239	13	22.1R
	S/2004 S 13	906		18,450	6	24.5R
	S/2004 S 17	986		18,600	4	25.2R
	Narvi	956.19		18,719	7	23.8R
	Mundilfari	951.56		18,722	6	23.8R
	S/2004 S 15	1,008		18,750	6	24.2R
	S/2004 S 10	1,026		19,350	6	24.4R
	Suttung	1,016.51		19,465	6	23.9R
	S/2004 S 12	1,048		19,650	5	24.8R
	S/2004 S 18	1,052		19,650	7	23.8R
	S/2004 S 7	1,103		19,800	6	24.5R
	S/2004 S 9	1,077		19,800	5	24.7R
	S/2004 S 14	1,081		19,950	6	24.4R
	Thrym	1,091.76		20,219	6	23.9R
	S/2004 S 8	1,355		22,200	6	24.6R
	S/2004 S 16	1,271		22,200	4	25R
	Ymir	1,315.33		23,130	16	21.7R
Uranus	Cordelia	0.34	0' 04"	50	40	23.6
	Ophelia	0.38	0' 04"	54	43	23.3
	Bianca	0.44	0' 04"	59	51	22.5
	Cressida	0.46	0' 05"	62	80	21.6
	Desdemona	0.47	0' 05"	63	64	22.0
	Juliet	0.49	0' 05"	64	94	21.1
	Portia	0.51	0' 05"	66	135	20.4
	Rosalind	0.56	0' 05"	70	72	21.8
	S/2003 U 2			75	10	26
	Belinda	0.62	0' 06"	75	81	21.5
	S/1986 U 10	0.64		76	20	24
	Puck	0.76	0' 07"	86	162	19.8
	S/2003 U 1			98	20	26
	Miranda	1.41	0' 10"	130	472	15.8
	Ariel	2.52	0' 14"	191	1,158	13.7
	Umbriel	4.14	0' 20"	266	1,097	14.5
	Titania	8.71	0' 33"	436	1,578	13.5
	Oberon	13.46	0' 44"	584	1,523	13.7
	S/2001 U 3	266.6		4,276	22	25
	Caliban	579.73	8' 56"	7,231	98	22.4
	Stephano	677.37		8,004	20	24.1
	Trinculo	759.03		8,578	18	25.4R
	Sycorax	1,288.28	15' 26"	12,179	190	20.8
	S/2003 U 3	1,694.8		14,345	20	25.2R
	Prospero	1,977.29		16,243	30	23.2
	Setebos	2,234.77		17,501	30	23.3
	S/2001 U 2	2,823.40		20,901	21	25.1
Neptune	Naiad	0.29	0' 02"	48	66	23.9
	Thalassa	0.31	0' 02"	50	82	23.3
	Despina	0.34	0' 02"	53	150	22.0
	Galatea	0.43	0' 03"	62	176	21.9
	Larissa	0.56	0' 03"	74	194	21.5
	Proteus	1.12	0' 06"	118	420	19.8
	Triton	5.88	0' 17"	355	2,707	13.5
	Nereid	360.14	4' 21"	5,513	340	19.7
	S/2002 N 1	1,874.83		15,686	48	25.0R
	S/2002 N 2	2,405.98		19,345	48	25.0R
	S/2002 N 3	2,674.87		20,723	48	25.0R
	S/2003 N 1	9,136.11		46,738	28	26.0R
	S/2002 N 4	9,007.10		47,280	120	
Pluto	Charon	6.39	<1"	19	1,186	17.3

The table covers the currently known satellites of the Solar System (as of September 2005). Note a number of the satellites above are recent discoveries and have not yet been named. Instead they have a preliminary designation such as S/2003 J 2. Note: magnitudes followed by R are red magnitudes.

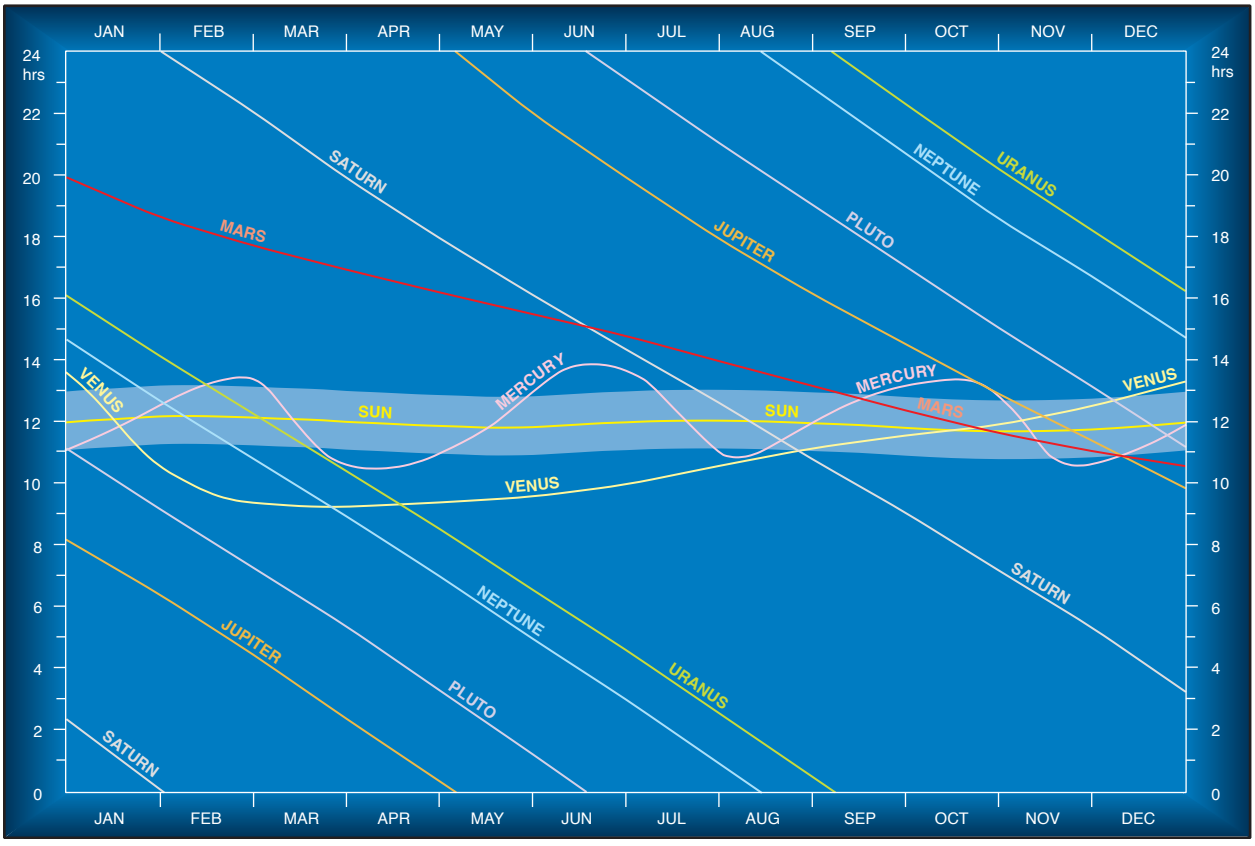
DECLINATIONS of the SUN and PLANETS

In general, the further south a planet is (negative declination), the higher in the northern sky it is, as seen from most of Australia. The higher in the sky, the less atmosphere you have to look through and the more stable the image is (less prone to turbulence). This can be particularly relevant when trying to observe a planet under high magnification.



MERIDIAN PASSAGE of the SUN and PLANETS

The time of meridian passage for a planet is when it is due north and at its highest point in the sky. For the outer planets this is certainly looked upon as the best time to observe when you are looking through the least amount of atmosphere. The time for the Sun is close to midday (12hrs). When a planet crosses from the bottom of the diagram (0 hours) to the top (24 hours) it is at opposition and visible the whole night.



SUN

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	18 45 00	- 23 02 08	20 57 27	- 17 13 17	22 46 48	- 07 45 08	00 40 37	+ 04 22 14	02 31 59	+ 14 56 35	04 34 44	+ 21 59 34
2	18 49 25	- 22 57 09	21 01 31	- 16 56 11	22 50 33	- 07 22 19	00 44 16	+ 04 45 23	02 35 48	+ 15 14 43	04 38 50	+ 22 07 41
3	18 53 50	- 22 51 43	21 05 35	- 16 38 48	22 54 17	- 06 59 24	00 47 55	+ 05 08 28	02 39 38	+ 15 32 36	04 42 56	+ 22 15 25
4	18 58 14	- 22 45 50	21 09 38	- 16 21 07	22 58 01	- 06 36 23	00 51 33	+ 05 31 26	02 43 28	+ 15 50 14	04 47 02	+ 22 22 46
5	19 02 38	- 22 39 29	21 13 40	- 16 03 09	23 01 45	- 06 13 17	00 55 13	+ 05 54 19	02 47 19	+ 16 07 36	04 51 09	+ 22 29 43
6	19 07 01	- 22 32 42	21 17 41	- 15 44 55	23 05 28	- 05 50 05	00 58 52	+ 06 17 05	02 51 11	+ 16 24 42	04 55 16	+ 22 36 17
7	19 11 24	- 22 25 28	21 21 42	- 15 26 25	23 09 11	- 05 26 49	01 02 31	+ 06 39 45	02 55 03	+ 16 41 31	04 59 24	+ 22 42 27
8	19 15 46	- 22 17 47	21 25 42	- 15 07 39	23 12 53	- 05 03 29	01 06 11	+ 07 02 18	02 58 55	+ 16 58 04	05 03 31	+ 22 48 13
9	19 20 08	- 22 09 40	21 29 40	- 14 48 38	23 16 35	- 04 40 05	01 09 51	+ 07 24 44	03 02 49	+ 17 14 19	05 07 39	+ 22 53 35
10	19 24 30	- 22 01 07	21 33 39	- 14 29 22	23 20 16	- 04 16 37	01 13 31	+ 07 47 02	03 06 42	+ 17 30 17	05 11 47	+ 22 58 33
11	19 28 50	- 21 52 08	21 37 36	- 14 09 51	23 23 57	- 03 53 07	01 17 11	+ 08 09 12	03 10 37	+ 17 45 58	05 15 56	+ 23 03 06
12	19 33 10	- 21 42 44	21 41 32	- 13 50 07	23 27 38	- 03 29 33	01 20 52	+ 08 31 13	03 14 31	+ 18 01 20	05 20 04	+ 23 07 16
13	19 37 30	- 21 32 55	21 45 28	- 13 30 09	23 31 18	- 03 05 57	01 24 33	+ 08 53 07	03 18 27	+ 18 16 25	05 24 13	+ 23 11 01
14	19 41 49	- 21 22 41	21 49 23	- 13 09 57	23 34 58	- 02 42 19	01 28 14	+ 09 14 51	03 22 23	+ 18 31 11	05 28 22	+ 23 14 21
15	19 46 07	- 21 12 02	21 53 17	- 12 49 33	23 38 38	- 02 18 40	01 31 56	+ 09 36 26	03 26 19	+ 18 45 38	05 32 31	+ 23 17 17
16	19 50 25	- 21 00 59	21 57 11	- 12 28 57	23 42 18	- 01 54 59	01 35 38	+ 09 57 52	03 30 16	+ 18 59 47	05 36 41	+ 23 19 48
17	19 54 42	- 20 49 31	22 01 04	- 12 08 08	23 45 57	- 01 31 17	01 39 20	+ 10 19 08	03 34 14	+ 19 13 36	05 40 50	+ 23 21 55
18	19 58 58	- 20 37 40	22 04 56	- 11 47 07	23 49 36	- 01 07 34	01 43 03	+ 10 40 13	03 38 12	+ 19 27 06	05 45 00	+ 23 23 37
19	20 03 13	- 20 25 25	22 08 47	- 11 25 56	23 53 15	- 00 43 51	01 46 46	+ 11 01 09	03 42 11	+ 19 40 16	05 49 09	+ 23 24 54
20	20 07 28	- 20 12 48	22 12 38	- 11 04 33	23 56 54	- 00 20 09	01 50 29	+ 11 21 53	03 46 10	+ 19 53 06	05 53 19	+ 23 25 46
21	20 11 42	- 19 59 47	22 16 28	- 10 43 00	00 00 33	+ 00 03 34	01 54 13	+ 11 42 26	03 50 10	+ 20 05 36	05 57 29	+ 23 26 14
22	20 15 56	- 19 46 24	22 20 18	- 10 21 17	00 04 12	+ 00 27 16	01 57 57	+ 12 02 48	03 54 11	+ 20 17 45	06 01 38	+ 23 26 17
23	20 20 08	- 19 32 39	22 24 07	- 09 59 25	00 07 50	+ 00 50 56	02 01 42	+ 12 22 59	03 58 12	+ 20 29 33	06 05 48	+ 23 25 55
24	20 24 20	- 19 18 32	22 27 55	- 09 37 23	00 11 29	+ 01 14 36	02 05 28	+ 12 42 57	04 02 14	+ 20 41 01	06 09 57	+ 23 25 08
25	20 28 31	- 19 04 04	22 31 43	- 09 15 12	00 15 07	+ 01 38 13	02 09 13	+ 13 02 42	04 06 16	+ 20 52 07	06 14 07	+ 23 23 56
26	20 32 41	- 18 49 14	22 35 30	- 08 52 52	00 18 46	+ 02 01 48	02 13 00	+ 13 22 15	04 10 18	+ 21 02 52	06 18 16	+ 23 22 20
27	20 36 51	- 18 34 04	22 39 16	- 08 30 25	00 22 24	+ 02 25 21	02 16 47	+ 13 41 35	04 14 22	+ 21 13 14	06 22 26	+ 23 20 18
28	20 41 00	- 18 18 34	22 43 02	- 08 07 50	00 26 03	+ 02 48 51	02 20 34	+ 14 00 41	04 18 25	+ 21 23 15	06 26 35	+ 23 17 53
29	20 45 08	- 18 02 43			00 29 41	+ 03 12 18	02 24 22	+ 14 19 33	04 22 29	+ 21 32 54	06 30 44	+ 23 15 02
30	20 49 15	- 17 46 33			00 33 20	+ 03 35 41	02 28 10	+ 14 38 11	04 26 34	+ 21 42 10	06 34 52	+ 23 11 47
31	20 53 21	- 17 30 05			00 36 58	+ 03 59 00			04 30 39	+ 21 51 03		

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	06 39 01	+ 23 08 08	08 43 53	+ 18 07 32	10 39 57	+ 08 26 23	12 27 54	- 03 00 46	14 23 50	- 14 16 59	16 27 17	- 21 43 44
2	06 43 09	+ 23 04 05	08 47 46	+ 17 52 25	10 43 34	+ 08 04 37	12 31 31	- 03 24 02	14 27 45	- 14 36 11	16 31 36	- 21 53 03
3	06 47 17	+ 22 59 37	08 51 38	+ 17 37 01	10 47 11	+ 07 42 44	12 35 08	- 03 47 16	14 31 41	- 14 55 08	16 35 55	- 22 01 56
4	06 51 24	+ 22 54 45	08 55 29	+ 17 21 19	10 50 48	+ 07 20 44	12 38 46	- 04 10 26	14 35 37	- 15 13 51	16 40 15	- 22 10 24
5	06 55 32	+ 22 49 29	08 59 20	+ 17 05 21	10 54 25	+ 06 58 36	12 42 24	- 04 33 34	14 39 35	- 15 32 20	16 44 36	- 22 18 26
6	06 59 39	+ 22 43 50	09 03 11	+ 16 49 06	10 58 01	+ 06 36 22	12 46 02	- 04 56 38	14 43 33	- 15 50 32	16 48 57	- 22 26 02
7	07 03 45	+ 22 37 47	09 07 01	+ 16 32 35	11 01 38	+ 06 14 01	12 49 41	- 05 19 39	14 47 32	- 16 08 29	16 53 19	- 22 33 12
8	07 07 51	+ 22 31 20	09 10 50	+ 16 15 48	11 05 14	+ 05 51 34	12 53 20	- 05 42 35	14 51 31	- 16 26 10	16 57 41	- 22 39 56
9	07 11 57	+ 22 24 31	09 14 38	+ 15 58 46	11 08 50	+ 05 29 02	12 57 00	- 06 05 28	14 55 32	- 16 43 35	17 02 04	- 22 46 13
10	07 16 02	+ 22 17 18	09 18 27	+ 15 41 28	11 12 25	+ 05 06 24	13 00 40	- 06 28 15	14 59 33	- 17 00 43	17 06 27	- 22 52 04
11	07 20 07	+ 22 09 42	09 22 14	+ 15 23 56	11 16 01	+ 04 43 40	13 04 20	- 06 50 57	15 03 36	- 17 17 33	17 10 51	- 22 57 27
12	07 24 12	+ 22 01 43	09 26 01	+ 15 06 08	11 19 36	+ 04 20 52	13 08 02	- 07 13 34	15 07 39	- 17 34 06	17 15 15	- 23 02 23
13	07 28 16	+ 21 53 21	09 29 47	+ 14 48 06	11 23 11	+ 03 57 59	13 11 43	- 07 36 06	15 11 43	- 17 50 20	17 19 39	- 23 06 52
14	07 32 19	+ 21 44 37	09 33 33	+ 14 29 50	11 26 47	+ 03 35 01	13 15 25	- 07 58 31	15 15 48	- 18 06 17	17 24 04	- 23 10 53
15	07 36 22	+ 21 35 31	09 37 18	+ 14 11 19	11 30 22	+ 03 12 00	13 19 08	- 08 20 49	15 19 54	- 18 21 54	17 28 29	- 23 14 27
16	07 40 25	+ 21 26 03	09 41 03	+ 13 52 35	11 33 57	+ 02 48 54	13 22 51	- 08 43 01	15 24 00	- 18 37 12	17 32 55	- 23 17 33
17	07 44 27	+ 21 16 13	09 44 47	+ 13 33 38	11 37 32	+ 02 25 46	13 26 35	- 09 05 06	15 28 08	- 18 52 10	17 37 21	- 23 20 11
18	07 48 29	+ 21 06 01	09 48 31	+ 13 14 28	11 41 07	+ 02 02 34	13 30 19	- 09 27 02	15 32 16	- 19 06 48	17 41 46	- 23 22 21
19	07 52 30	+ 20 55 28	09 52 14	+ 12 55 05	11 44 43	+ 01 39 20	13 34 04	- 09 48 51	15 36 25	- 19 21 06	17 46 13	- 23 24 03
20	07 56 30	+ 20 44 33	09 55 57	+ 12 35 30	11 48 18	+ 01 16 04	13 37 50	- 10 10 31	15 40 35	- 19 35 03	17 50 39	- 23 25 16
21	08 00 30	+ 20 33 17	09 59 39	+ 12 15 42	11 51 53	+ 00 52 45	13 41 36	- 10 32 02	15 44 46	- 19 48 38	17 55 05	- 23 26 01
22	08 04 30	+ 20 21 41	10 03 21	+ 11 55 43	11 55 29	+ 00 29 25	13 45 23	- 10 53 24	15 48 58	- 20 01 52	17 59 32	- 23 26 19
23	08 08 29	+ 20 09 44	10 07 03	+ 11 35 33	11 59 04	+ 00 06 04	13 49 10	- 11 14 37	15 53 10	- 20 14 44	18 03 58	- 23 26 07
24	08 12 27	+ 19 57 27	10 10 44	+ 11 15 11	12 02 40	- 00 17 18	13 52 59	- 11 35 38	15 57 24	- 20 27 14	18 08 25	- 23 25 28
25	08 16 25	+ 19 44 49	10 14 24	+ 10 54 39	12 06 15	- 00 40 41	13 56 48	- 11 56 30	16 01 38	- 20 39 20	18 12 51	- 23 24 20
26	08 20 22	+ 19 31 52	10 18 04	+ 10 33 56	12 09 51	- 01 04 04	14 00 37	- 12 17 10	16 05 52	- 20 51 04	18 17 18	- 23 22 44
27	08 24 19	+ 19 18 36	10 21 44	+ 10 13 04	12 13 27	- 01 27 26	14 04 28	- 12 37 39	16 10 08	- 21 02 24	18 21 44	- 23 20 40
28	08 28 15	+ 19 05 00	10 25 23	+ 09 52 02	12 17 04	- 01 50 48	14 08 19	- 12 57 56	16 14 24	- 21 13 20	18 26 10	- 23 18 08
29	08 32 10	+ 18 51 06	10 29 02	+ 09 30 50	12 20 40	- 02 14 09	14 12 10	- 13 18 01	16 18 41	- 21 23 53	18 30 36	- 23 15 07
30	08 36 05	+ 18 36 53	10 32 41	+ 09 09 29	12 24 17	- 02 37 28	14 16 03	- 13 37 54	16 22 58	- 21 34 01	18 35 01	- 23 11 39
31	08 39 59	+ 18 22 21	10 36 19	+ 08 48 00			14 19 56	- 13 57 33			18 39 27	- 23 07 43

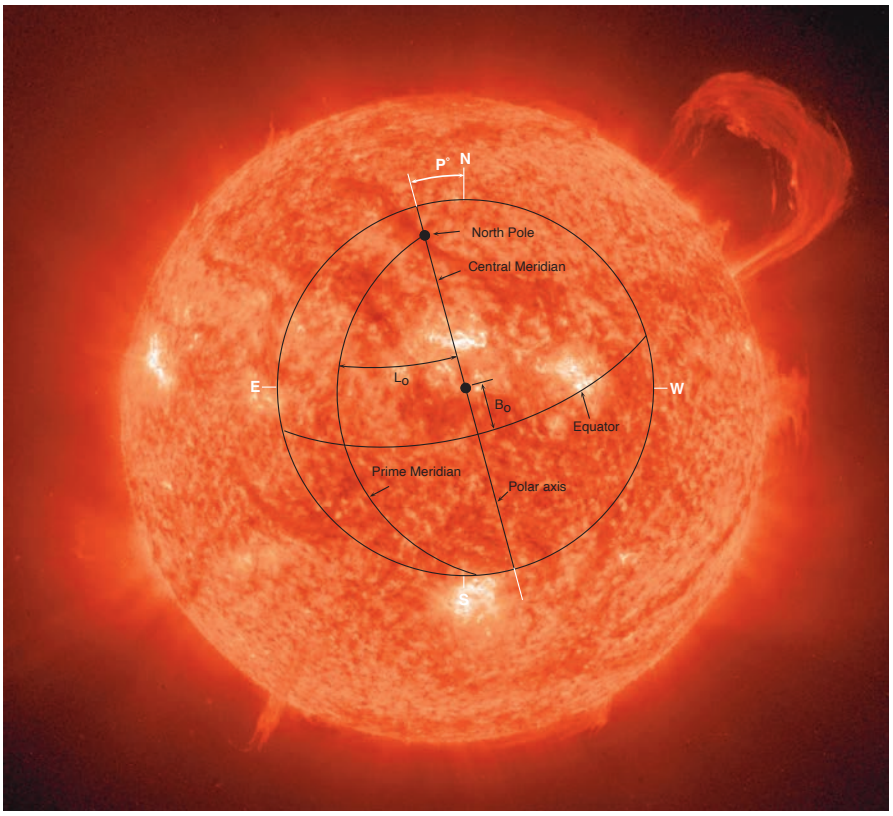
SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

	ADELAIDE (CST)				BRISBANE (EST)				CANBERRA (EST)				DARWIN (CST)				
	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	
	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	
Jan 7	3:25	5:10	19:33	21:18	3:29	5:00	18:48	20:19	3:11	4:57	19:22	21:07	5:10	6:29	19:18	20:36	Jan 7
14	3:34	5:16	19:32	21:15	3:35	5:05	18:48	20:18	3:20	5:03	19:21	21:04	5:15	6:32	19:19	20:37	14
21	3:43	5:23	19:30	21:10	3:43	5:11	18:47	20:15	3:29	5:10	19:19	20:59	5:20	6:36	19:20	20:37	21
28	3:53	5:31	19:26	21:03	3:50	5:17	18:44	20:11	3:39	5:18	19:15	20:53	5:24	6:40	19:20	20:36	28
Feb 4	4:03	5:38	19:21	20:56	3:57	5:23	18:41	20:06	3:49	5:25	19:09	20:45	5:28	6:43	19:19	20:34	Feb 4
11	4:12	5:45	19:14	20:47	4:04	5:28	18:36	19:59	3:59	5:32	19:03	20:36	5:32	6:45	19:17	20:31	11
18	4:21	5:52	19:07	20:37	4:11	5:33	18:30	19:52	4:08	5:39	18:55	20:26	5:34	6:47	19:15	20:27	18
25	4:30	5:58	18:58	20:27	4:17	5:38	18:24	19:44	4:17	5:46	18:47	20:15	5:37	6:49	19:12	20:23	25
Mar 4	4:38	6:05	18:50	20:16	4:23	5:42	18:17	19:36	4:25	5:52	18:38	20:05	5:38	6:50	19:08	20:19	Mar 4
11	4:45	6:11	18:40	20:06	4:28	5:46	18:10	19:28	4:32	5:59	18:28	19:54	5:40	6:50	19:04	20:14	11
18	4:52	6:17	18:30	19:55	4:32	5:50	18:02	19:20	4:39	6:04	18:18	19:43	5:41	6:51	18:59	20:10	18
25	4:58	6:22	18:21	19:45	4:36	5:54	17:54	19:12	4:46	6:10	18:08	19:33	5:41	6:51	18:55	20:05	25
Apr 1	5:04	6:28	18:11	19:35	4:40	5:57	17:46	19:04	4:51	6:16	17:59	19:23	5:41	6:52	18:50	20:01	Apr 1
8	5:09	6:33	18:01	19:25	4:43	6:01	17:39	18:56	4:57	6:21	17:49	19:13	5:41	6:52	18:46	19:57	8
15	5:15	6:39	17:52	19:16	4:47	6:05	17:31	18:49	5:02	6:27	17:40	19:04	5:41	6:52	18:42	19:53	15
22	5:19	6:44	17:44	19:08	4:50	6:08	17:25	18:43	5:07	6:33	17:31	18:56	5:41	6:53	18:38	19:50	22
29	5:24	6:50	17:36	19:01	4:53	6:12	17:18	18:37	5:12	6:38	17:23	18:49	5:42	6:54	18:35	19:47	29
May 6	5:29	6:55	17:29	18:55	4:56	6:16	17:13	18:33	5:17	6:44	17:16	18:43	5:42	6:55	18:32	19:45	May 6
13	5:34	7:01	17:23	18:50	4:59	6:20	17:08	18:29	5:22	6:49	17:10	18:38	5:43	6:56	18:30	19:44	13
20	5:38	7:06	17:18	18:46	5:02	6:24	17:05	18:26	5:26	6:55	17:05	18:33	5:44	6:58	18:29	19:43	20
27	5:42	7:11	17:14	18:43	5:05	6:28	17:02	18:24	5:30	7:00	17:01	18:31	5:45	7:00	18:28	19:43	27
Jun 3	5:46	7:15	17:12	18:41	5:08	6:31	17:01	18:24	5:34	7:04	16:59	18:29	5:47	7:02	18:28	19:44	Jun 3
10	5:49	7:19	17:11	18:41	5:11	6:34	17:00	18:24	5:37	7:08	16:58	18:28	5:48	7:04	18:29	19:44	10
17	5:51	7:22	17:11	18:41	5:13	6:37	17:01	18:24	5:40	7:11	16:58	18:29	5:50	7:06	18:30	19:46	17
24	5:53	7:24	17:12	18:43	5:15	6:38	17:02	18:26	5:41	7:12	16:59	18:30	5:52	7:07	18:31	19:47	24
Jul 1	5:54	7:24	17:15	18:45	5:16	6:39	17:05	18:28	5:42	7:13	17:02	18:33	5:53	7:09	18:33	19:49	Jul 1
8	5:53	7:23	17:18	18:48	5:16	6:39	17:07	18:30	5:42	7:12	17:05	18:35	5:54	7:09	18:35	19:50	8
15	5:52	7:21	17:22	18:51	5:15	6:37	17:11	18:33	5:40	7:10	17:09	18:39	5:54	7:09	18:37	19:52	15
22	5:49	7:18	17:27	18:55	5:13	6:35	17:14	18:36	5:37	7:06	17:14	18:43	5:54	7:09	18:39	19:53	22
29	5:45	7:13	17:32	18:59	5:11	6:31	17:18	18:39	5:34	7:01	17:19	18:47	5:53	7:07	18:40	19:54	29
Aug 5	5:40	7:07	17:37	19:03	5:07	6:27	17:21	18:41	5:28	6:55	17:24	18:51	5:52	7:05	18:41	19:54	Aug 5
12	5:34	7:00	17:42	19:08	5:02	6:22	17:25	18:44	5:22	6:48	17:29	18:55	5:50	7:02	18:42	19:55	12
19	5:27	6:52	17:47	19:12	4:57	6:15	17:28	18:47	5:15	6:40	17:34	19:00	5:47	6:59	18:43	19:54	19
26	5:19	6:43	17:52	19:17	4:50	6:08	17:32	18:50	5:07	6:32	17:40	19:04	5:44	6:55	18:43	19:54	26
Sep 2	5:10	6:34	17:57	19:21	4:43	6:01	17:35	18:53	4:58	6:22	17:45	19:09	5:40	6:51	18:43	19:54	Sep 2
9	5:01	6:25	18:02	19:26	4:36	5:53	17:38	18:56	4:48	6:13	17:50	19:14	5:36	6:46	18:43	19:54	9
16	4:51	6:15	18:07	19:31	4:28	5:45	17:41	18:59	4:38	6:03	17:55	19:19	5:31	6:41	18:43	19:53	16
23	4:40	6:05	18:12	19:37	4:19	5:37	17:44	19:02	4:28	5:52	18:00	19:25	5:26	6:36	18:43	19:53	23
30	4:29	5:55	18:18	19:43	4:11	5:29	17:48	19:06	4:17	5:42	18:06	19:31	5:21	6:32	18:43	19:54	30
Oct 7	4:19	5:45	18:23	19:49	4:02	5:21	17:51	19:10	4:06	5:32	18:11	19:38	5:16	6:27	18:43	19:54	Oct 7
14	4:08	5:35	18:29	19:57	3:54	5:14	17:55	19:15	3:55	5:23	18:17	19:45	5:11	6:23	18:44	19:55	14
21	3:57	5:26	18:35	20:04	3:46	5:07	17:59	19:20	3:44	5:14	18:23	19:53	5:07	6:19	18:45	19:57	21
28	3:47	5:18	18:41	20:13	3:38	5:00	18:03	19:26	3:34	5:06	18:29	20:02	5:03	6:16	18:46	19:59	28
Nov 4	3:37	5:11	18:48	20:22	3:31	4:55	18:08	19:33	3:24	4:58	18:36	20:11	4:59	6:13	18:48	20:02	Nov 4
11	3:29	5:05	18:55	20:31	3:25	4:51	18:14	19:40	3:15	4:52	18:43	20:20	4:57	6:12	18:50	20:06	11
18	3:21	5:00	19:02	20:41	3:20	4:47	18:19	19:47	3:08	4:47	18:50	20:30	4:55	6:11	18:53	20:09	18
25	3:16	4:57	19:08	20:50	3:16	4:45	18:24	19:54	3:02	4:44	18:57	20:40	4:54	6:11	18:57	20:14	25
Dec 2	3:11	4:55	19:15	20:59	3:14	4:45	18:30	20:01	2:58	4:42	19:04	20:48	4:55	6:12	19:00	20:18	Dec 2
9	3:09	4:55	19:21	21:06	3:14	4:45	18:35	20:07	2:56	4:42	19:10	20:56	4:56	6:14	19:04	20:23	9
16	3:10	4:56	19:26	21:12	3:15	4:47	18:40	20:12	2:56	4:43	19:15	21:02	4:58	6:17	19:08	20:27	16
23	3:12	4:59	19:30	21:16	3:18	4:50	18:43	20:16	2:58	4:46	19:18	21:06	5:01	6:20	19:12	20:30	23
30	3:17	5:03	19:32	21:18	3:22	4:54	18:46	20:18	3:03	4:50	19:21	21:08	5:05	6:24	19:15	20:33	30

SUN RISE, SUN SET and ASTRONOMICAL TWILIGHT

	HOBART (EST)				MELBOURNE (EST)				PERTH (WST)				SYDNEY (EST)				
	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	Twilight	Sun		Twilight	
	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	Begin	Rise	Set	End	
Jan 7	2:29	4:42	19:52	22:04	3:14	5:06	19:46	21:38	3:40	5:19	19:27	21:05	3:09	4:52	19:10	20:52	Jan 7
14	2:41	4:50	19:50	21:58	3:23	5:13	19:44	21:34	3:48	5:25	19:26	21:03	3:18	4:58	19:09	20:50	14
21	2:55	4:58	19:46	21:48	3:33	5:21	19:41	21:28	3:56	5:31	19:24	20:59	3:26	5:05	19:07	20:45	21
28	3:09	5:07	19:40	21:37	3:45	5:29	19:37	21:20	4:05	5:38	19:21	20:54	3:36	5:12	19:03	20:39	28
Feb 4	3:23	5:17	19:32	21:25	3:56	5:37	19:31	21:11	4:13	5:44	19:16	20:47	3:45	5:19	18:58	20:32	Feb 4
11	3:37	5:26	19:24	21:12	4:07	5:44	19:23	21:01	4:22	5:51	19:11	20:39	3:55	5:26	18:52	20:23	11
18	3:51	5:36	19:14	20:58	4:17	5:52	19:15	20:50	4:30	5:57	19:04	20:30	4:03	5:32	18:45	20:14	18
25	4:03	5:45	19:03	20:44	4:27	6:00	19:06	20:38	4:37	6:02	18:57	20:21	4:11	5:39	18:37	20:04	25
Mar 4	4:14	5:54	18:52	20:30	4:36	6:07	18:56	20:27	4:44	6:08	18:48	20:12	4:19	5:45	18:28	19:54	Mar 4
11	4:25	6:02	18:40	20:16	4:44	6:14	18:46	20:15	4:51	6:13	18:40	20:02	4:26	5:51	18:19	19:44	11
18	4:35	6:11	18:27	20:03	4:52	6:20	18:35	20:03	4:56	6:18	18:31	19:53	4:32	5:56	18:10	19:33	18
25	4:44	6:19	18:15	19:49	4:59	6:27	18:25	19:52	5:02	6:23	18:22	19:43	4:38	6:02	18:00	19:23	25
Apr 1	4:53	6:27	18:03	19:37	5:06	6:33	18:14	19:41	5:07	6:28	18:13	19:34	4:44	6:07	17:51	19:14	Apr 1
8	5:01	6:35	17:51	19:25	5:13	6:40	18:04	19:31	5:11	6:32	18:04	19:25	4:49	6:12	17:42	19:04	8
15	5:08	6:43	17:39	19:13	5:19	6:46	17:54	19:21	5:16	6:37	17:56	19:17	4:54	6:17	17:33	18:56	15
22	5:16	6:51	17:28	19:03	5:24	6:52	17:44	19:12	5:20	6:42	17:48	19:10	4:59	6:22	17:24	18:48	22
29	5:23	6:58	17:18	18:54	5:30	6:59	17:36	19:04	5:24	6:47	17:41	19:04	5:03	6:28	17:17	18:41	29
May 6	5:29	7:06	17:09	18:46	5:35	7:05	17:28	18:58	5:28	6:52	17:35	18:58	5:08	6:33	17:10	18:35	May 6
13	5:36	7:14	17:01	18:39	5:40	7:11	17:21	18:52	5:32	6:56	17:29	18:54	5:12	6:38	17:04	18:30	13
20	5:42	7:21	16:54	18:33	5:45	7:17	17:16	18:47	5:36	7:01	17:25	18:50	5:16	6:43	16:59	18:26	20
27	5:47	7:27	16:49	18:29	5:50	7:23	17:11	18:44	5:40	7:05	17:22	18:48	5:20	6:48	16:56	18:24	27
Jun 3	5:52	7:33	16:45	18:26	5:54	7:27	17:09	18:42	5:43	7:09	17:20	18:46	5:24	6:52	16:54	18:22	Jun 3
10	5:56	7:38	16:43	18:25	5:57	7:31	17:07	18:41	5:46	7:13	17:19	18:46	5:27	6:56	16:53	18:22	10
17	5:58	7:41	16:43	18:25	6:00	7:34	17:07	18:42	5:48	7:15	17:19	18:47	5:29	6:59	16:53	18:22	17
24	6:00	7:43	16:44	18:27	6:02	7:36	17:09	18:43	5:50	7:17	17:21	18:48	5:31	7:00	16:54	18:24	24
Jul 1	6:01	7:43	16:47	18:29	6:02	7:36	17:11	18:45	5:51	7:18	17:23	18:50	5:32	7:01	16:57	18:26	Jul 1
8	6:00	7:41	16:51	18:33	6:02	7:35	17:15	18:49	5:50	7:17	17:26	18:53	5:31	7:00	17:00	18:29	8
15	5:57	7:38	16:57	18:37	6:00	7:33	17:19	18:52	5:49	7:15	17:30	18:56	5:30	6:58	17:04	18:32	15
22	5:53	7:33	17:03	18:42	5:57	7:29	17:24	18:56	5:47	7:12	17:34	18:59	5:28	6:55	17:08	18:36	22
29	5:48	7:26	17:09	18:48	5:52	7:23	17:30	19:01	5:44	7:08	17:38	19:03	5:24	6:50	17:13	18:40	29
Aug 5	5:41	7:18	17:16	18:53	5:47	7:17	17:36	19:06	5:39	7:03	17:43	19:07	5:19	6:45	17:18	18:43	Aug 5
12	5:33	7:09	17:24	19:00	5:40	7:09	17:42	19:11	5:34	6:56	17:47	19:10	5:13	6:38	17:23	18:48	12
19	5:24	6:59	17:31	19:06	5:32	7:01	17:47	19:16	5:27	6:49	17:52	19:14	5:06	6:30	17:28	18:52	19
26	5:14	6:48	17:38	19:13	5:24	6:51	17:53	19:21	5:20	6:41	17:56	19:18	4:58	6:22	17:33	18:56	26
Sep 2	5:03	6:37	17:46	19:20	5:14	6:41	17:59	19:27	5:12	6:33	18:00	19:22	4:50	6:13	17:37	19:00	Sep 2
9	4:51	6:25	17:53	19:27	5:03	6:31	18:05	19:32	5:03	6:24	18:05	19:26	4:41	6:03	17:42	19:05	9
16	4:38	6:12	18:01	19:35	4:53	6:20	18:11	19:38	4:54	6:15	18:09	19:30	4:31	5:54	17:47	19:10	16
23	4:25	6:00	18:08	19:44	4:41	6:09	18:17	19:45	4:44	6:06	18:13	19:35	4:21	5:44	17:52	19:15	23
30	4:11	5:47	18:16	19:53	4:29	5:58	18:23	19:52	4:34	5:56	18:18	19:40	4:10	5:34	17:57	19:21	30
Oct 7	3:57	5:35	18:24	20:02	4:17	5:47	18:29	20:00	4:24	5:47	18:22	19:45	4:00	5:25	18:02	19:27	Oct 7
14	3:43	5:23	18:32	20:13	4:05	5:37	18:36	20:08	4:15	5:39	18:27	19:52	3:49	5:16	18:07	19:34	14
21	3:29	5:12	18:41	20:24	3:54	5:27	18:43	20:17	4:05	5:31	18:32	19:58	3:39	5:07	18:13	19:41	21
28	3:15	5:01	18:50	20:37	3:42	5:18	18:50	20:26	3:56	5:23	18:38	20:06	3:29	4:59	18:19	19:49	28
Nov 4	3:01	4:52	18:59	20:50	3:31	5:10	18:57	20:37	3:48	5:17	18:44	20:14	3:20	4:52	18:25	19:58	Nov 4
11	2:48	4:43	19:08	21:03	3:22	5:04	19:05	20:47	3:40	5:12	18:50	20:22	3:12	4:46	18:32	20:07	11
18	2:36	4:36	19:17	21:17	3:13	4:58	19:13	20:58	3:34	5:07	18:56	20:30	3:05	4:42	18:39	20:16	18
25	2:26	4:31	19:25	21:31	3:06	4:54	19:20	21:09	3:29	5:05	19:03	20:39	2:59	4:39	18:45	20:25	25
Dec 2	2:18	4:28	19:33	21:44	3:01	4:52	19:27	21:19	3:26	5:03	19:09	20:47	2:56	4:37	18:52	20:33	Dec 2
9	2:12	4:26	19:41	21:55	2:58	4:51	19:33	21:27	3:24	5:03	19:14	20:53	2:54	4:37	18:57	20:41	9
16	2:10	4:27	19:46	22:03	2:57	4:52	19:39	21:34	3:25	5:05	19:19	20:59	2:54	4:38	19:02	20:47	16
23	2:12	4:30	19:50	22:08	3:00	4:55	19:43	21:38	3:28	5:08	19:23	21:03	2:57	4:41	19:06	20:51	23
30	2:18	4:34	19:52	22:08	3:05	4:59	19:45	21:40	3:32	5:12	19:25	21:05	3:02	4:46	19:09	20:53	30

ORIENTATION OF THE SUN



P ° Position angle of Polar Axis.
(+ when pole east of north point, – if west)

B_o° Heliocentric Latitude of centre of Sun

L_o° Heliocentric Longitude of centre of Sun

At the date of commencement of each synodic rotation period the value of L_o is zero; that is, the prime meridian passes through the central point of the disk.

The rotation period of the Sun depends on latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is 27.28 days.

Example for Calculating Heliocentric Longitude

You wish to calculate the L_o value for Aug 18 at 2pm WST.

2pm WST is 6 hours UT (0 hr UT is 8am WST). From the table the value for Aug 18 (0 hr UT) is the value for Aug 12 (171.9°) plus 6 days which from the daily variation table is –79.1°. Then you add the value for 6 hours, which is –3.3°. The calculation becomes:

171.9° + (–79.1°) + (–3.3°) = 89.5°

(If negative you need to add 360°)

Image of a huge, handle-shaped prominence taken on September 14, 1999. Prominences are huge clouds of relatively cool dense plasma suspended in the Sun's hot, thin corona. At times, they can erupt, escaping the Sun's atmosphere. Emission in this spectral line shows the upper chromosphere at a temperature of about 60,000 degrees K. Every feature in the image traces magnetic field structure. The hottest areas appear almost white, while the darker red areas indicate cooler temperatures. Courtesy of SOHO/EIT consortium. SOHO is a project of international cooperation between ESA and NASA.

SYNODIC ROTATION NUMBERS (UT)

Rotation	Month	d.dd
2039	Jan	18.95
2040	Feb	15.29
2041	Mar	14.62
2042	Apr	10.91
2043	May	8.16
2044	Jun	4.37
2045	Jul	1.57
2046	Jul	28.78
2047	Aug	25.01
2048	Sep	21.27
2049	Oct	18.55
2050	Nov	14.85
2051	Dec	12.17

Date		P°	B_o°	L_o°
Jan	7	- 0.8	- 3.7	157.3
	14	- 4.1	- 4.4	065.1
	21	- 7.4	- 5.1	332.9
	28	- 10.5	- 5.7	240.7
Feb	4	- 13.3	- 6.2	148.6
	11	- 16.0	- 6.6	056.4
	18	- 18.3	- 7.0	324.2
	25	- 20.4	- 7.2	232.1
Mar	4	- 22.2	- 7.2	139.9
	11	- 23.7	- 7.2	047.6
	18	- 24.9	- 7.1	315.4
	25	- 25.7	- 6.9	223.1
Apr	1	- 26.2	- 6.6	130.7
	8	- 26.3	- 6.1	038.4
	15	- 26.1	- 5.6	306.0
	22	- 25.5	- 5.0	213.5
	29	- 24.5	- 4.4	121.0
May	6	- 23.2	- 3.7	028.5
	13	- 21.6	- 2.9	296.0
	20	- 19.6	- 2.1	203.4
	27	- 17.3	- 1.3	110.8
Jun	3	- 14.7	- 0.5	018.1
	10	- 12.0	+ 0.4	285.5
	17	- 9.0	+ 1.2	192.8
	24	- 5.9	+ 2.1	100.2
Jul	1	- 2.8	+ 2.9	007.5
	8	+ 0.4	+ 3.6	274.9
	15	+ 3.5	+ 4.3	182.2
	22	+ 6.6	+ 5.0	089.6
	29	+ 9.5	+ 5.5	357.0
Aug	5	+ 12.3	+ 6.1	264.4
	12	+ 14.9	+ 6.5	171.9
	19	+ 17.3	+ 6.8	079.4
	26	+ 19.4	+ 7.1	346.9
Sep	2	+ 21.3	+ 7.2	254.4
	9	+ 22.9	+ 7.3	161.9
	16	+ 24.2	+ 7.2	069.5
	23	+ 25.2	+ 7.0	337.1
	30	+ 25.9	+ 6.8	244.7
Oct	7	+ 26.2	+ 6.4	152.4
	14	+ 26.2	+ 6.0	060.0
	21	+ 25.9	+ 5.4	327.7
	28	+ 25.1	+ 4.8	235.4
Nov	4	+ 24.0	+ 4.1	143.1
	11	+ 22.5	+ 3.3	050.8
	18	+ 20.6	+ 2.5	318.5
	25	+ 18.4	+ 1.7	226.2
Dec	2	+ 15.8	+ 0.8	134.0
	9	+ 12.9	- 0.1	041.7
	16	+ 9.8	- 1.0	309.5
	23	+ 6.6	- 1.9	217.3
	30	+ 3.2	- 2.7	125.1

VARIATION OF L_o

DAILY		HOURLY							
1	– 13.2	1	– 0.6	7	– 3.8	13	– 7.1	19	– 10.4
2	– 26.4	2	– 1.1	8	– 4.4	14	– 7.7	20	– 11.0
3	– 39.6	3	– 1.7	9	– 4.9	15	– 8.2	21	– 11.5
4	– 52.7	4	– 2.2	10	– 5.5	16	– 8.8	22	– 12.1
5	– 65.9	5	– 2.8	11	– 6.0	17	– 9.3	23	– 12.6
6	– 79.1	6	– 3.3	12	– 6.6	18	– 9.9	24	– 13.2

SOLAR AND LUNAR ECLIPSES

During 2006 there are four eclipses, two of the Sun and two of the Moon. One solar eclipse is total and the other annular. One lunar eclipse is penumbral and the other partial.

Notes: Magnitudes quoted for lunar eclipses relate to the percentage of the lunar diameter that is either immersed in the Earth's umbral shadow (total and partial eclipses), or the penumbral shadow (penumbral eclipse): it is not a measure of brightness. Unless indicated otherwise, times listed in the tables below are in UT.

MARCH 14 / 15th

Penumbral eclipse of the Moon

The first eclipse of the year will not be visible to Australian observers. Those located in Europe and Africa will witness the entire event. The magnitude of the eclipse is 1.056 and the Moon will be totally immersed in the Earth's penumbral shadow. From Perth, Western Australia the Moon makes contact with the penumbral shadow about 30 minutes after the start of dawn on the morning of the 15th, but this will go undetected in the brightening sky.

Moon enters penumbra:	14th	21h 21.5m UT
Greatest eclipse:	14th	23h 47.4m
Moon leaves umbra:	15th	02h 13.4m

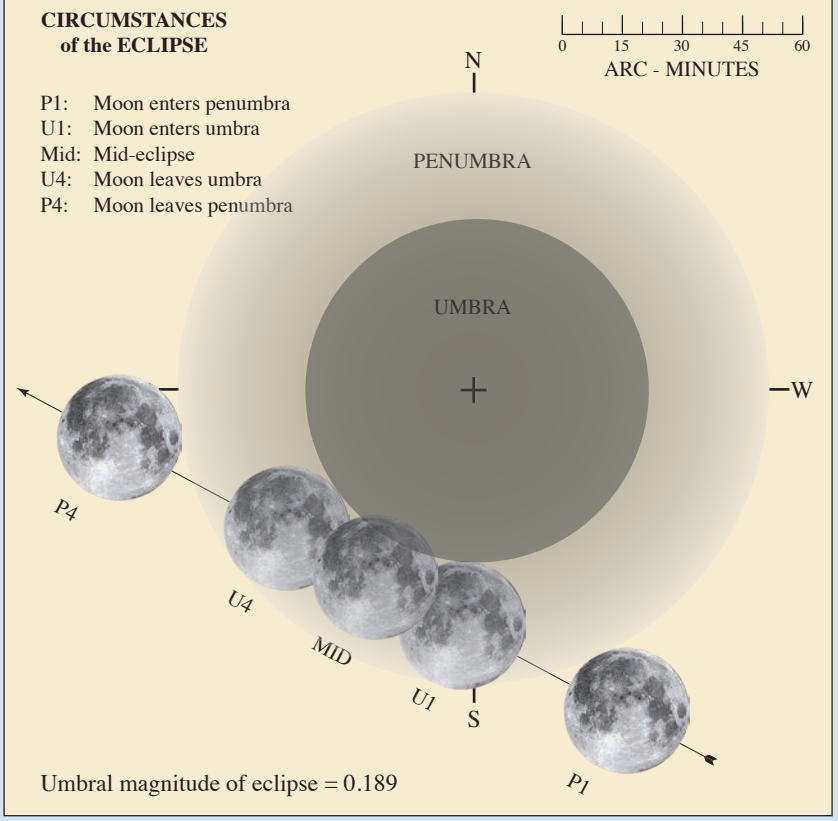
MARCH 29th

Total eclipse of the Sun

The path of the first solar eclipse of the year begins just south of the equator on the east coast of Brazil. It then crosses the Atlantic Ocean making landfall in Ghana. Traversing the African continent, the shadow then moves over Togo, Benin, Nigeria, Niger, Chad and Libya. The shadow then crosses the Mediterranean Sea, Turkey, the Black Sea, Georgia and finally Kazakhstan. Maximum eclipse of 4 minutes and 10.7 seconds occurs near the virtually inaccessible borders of Chad and Libya, and most eclipse chasers will be opting for Turkey as the preferred viewing site.

	U.T.	Long	Lat
Eclipse begins:	07h 36.8m	-22° 06.1'	-14° 27.7'
Central Eclipse at local noon	10h 33.2m	+22° 53.9'	+29° 37.2'
Eclipse ends:	12h 45.6m	+83° 03.3'	+43° 26.3'

PARTIAL LUNAR ECLIPSE - 7th SEPTEMBER 2006



SEPTEMBER 7th (8th for Australia) Partial Eclipse of the Moon

The year's second lunar eclipse is visible up to mid-eclipse from the eastern states and in its entirety from Western Australia. The eclipse magnitude is 0.189, resulting in a little less than 20% of the lunar diameter dipping into the umbral shadow at mid-eclipse. In the eastern states the eclipse begins in the early morning hours of September 8, and effectively ends during the umbral stage as the dawn sky takes over. From Western Australia the eclipse begins after midnight local time and ends at 5am. Generally the early stages of a lunar eclipse are not readily noticeable until half of the lunar diameter is within the Earth's weak penumbral shadow.

Penumbral Eclipse Begins	16h 42.2m UT	2:42am EST, 12:42am WST
Partial Eclipse Begins	18h 05.0m UT	4:05am EST, 2:05am WST
Mid-Eclipse	18h 51.3m UT	4:51am EST, 2:51am WST
Partial Eclipse Ends	19h 37.6m UT	5:38am EST, 3:38am WST
Penumbral Eclipse Ends	21h 00.3m UT	7:00am EST, 5:00am WST

SEPTEMBER 22nd Annular Eclipse of the Sun

The last of 2006's eclipses is an annular solar type beginning at sunrise over the South American countries of Guyana, Suriname, French Guiana and a tiny portion of northern Brazil. After leaving the coast the track travels south of the equator over the Atlantic Ocean, ending below South Africa. Maximum eclipse of 7 minutes and 4.0 seconds occurs over the Atlantic, however from Cayenne in French Guiana 5 minutes and 42 seconds of annularity can be enjoyed.

	Time (UT)	Longitude	Latitude
Eclipse begins:	08h 39.9m.	-41°50.9'	-14°17.0'
Central Eclipse at local noon:	12h 07.1m	-03°35.5'	-27°39.5'
Eclipse ends:	14h 40.2m	+47°54.8'	-44°24.1'

ADELAIDE (CST) MOON RISE AND SET BRISBANE (EST)

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:43	20:57	08:20	21:16	07:06	19:41	09:29	19:45
2	06:59	21:41	09:31	21:45	08:19	20:11	10:40	20:27
3	08:15	22:17	10:41	22:13	09:30	20:41	11:48	21:15
4	09:28	22:48	11:49	22:43	10:41	21:14	12:50	22:10
5	10:39	23:17	12:57	23:17	11:51	21:52	13:43	23:09
6	11:46	23:44	14:04	23:55	12:59	22:35	14:27	DNS
7	12:53	DNS	15:08	DNS	14:02	23:24	15:04	00:09
8	13:59	00:12	16:09	00:39	14:59	DNS	15:35	01:10
9	15:05	00:42	17:02	01:30	15:48	00:19	16:02	02:09
10	16:11	01:17	17:49	02:26	16:29	01:18	16:26	03:07
11	17:14	01:56	18:28	03:25	17:03	02:18	16:49	04:03
12	18:13	02:42	19:00	04:26	17:32	03:18	17:11	04:59
13	19:05	03:35	19:29	05:25	17:58	04:17	17:35	05:56
14	19:49	04:33	19:54	06:24	18:22	05:14	18:00	06:55
15	20:27	05:33	20:17	07:20	18:44	06:10	18:29	07:56
16	20:58	06:34	20:39	08:16	19:07	07:07	19:04	08:59
17	21:25	07:33	21:02	09:12	19:30	08:04	19:46	10:04
18	21:50	08:30	21:26	10:09	19:57	09:02	20:36	11:09
19	22:12	09:27	21:53	11:08	20:27	10:03	21:36	12:10
20	22:35	10:22	22:26	12:10	21:03	11:07	22:43	13:04
21	22:58	11:19	23:05	13:15	21:47	12:12	23:54	13:51
22	23:24	12:17	23:53	14:21	22:41	13:16	DNR	14:31
23	23:54	13:18	DNR	15:26	23:44	14:16	01:06	15:05
24	DNR	14:23	00:52	16:26	DNR	15:09	02:18	15:35
25	00:29	15:30	02:01	17:18	00:54	15:54	03:29	16:04
26	01:14	16:39	03:17	18:02	02:09	16:33	04:40	16:33
27	02:09	17:44	04:35	18:39	03:24	17:06	05:51	17:04
28	03:15	18:42	05:51	19:11	04:38	17:37	07:04	17:38
29	04:30	19:30			05:51	18:06	08:16	18:17
30	05:48	20:11			07:04	18:36	09:28	19:04
31	07:05	20:45			08:16	19:09		

	MAY		JUNE		JULY		AUGUST	
1	10:34	19:57	11:33	21:47	10:56	22:30	10:30	DNS
2	11:32	20:55	12:04	22:46	11:19	23:26	10:57	00:07
3	12:21	21:57	12:31	23:44	11:42	DNS	11:27	01:07
4	13:02	22:59	12:54	DNS	12:04	00:22	12:04	02:10
5	13:36	23:59	13:17	00:40	12:29	01:19	12:50	03:15
6	14:04	DNS	13:40	01:36	12:58	02:19	13:46	04:20
7	14:29	00:57	14:04	02:33	13:32	03:21	14:52	05:20
8	14:52	01:54	14:30	03:32	14:13	04:27	16:05	06:13
9	15:15	02:50	15:01	04:33	15:04	05:34	17:22	06:58
10	15:38	03:47	15:38	05:38	16:06	06:38	18:37	07:36
11	16:03	04:45	16:24	06:45	17:16	07:35	19:51	08:10
12	16:31	05:45	17:19	07:51	18:30	08:24	21:03	08:40
13	17:03	06:48	18:24	08:52	19:45	09:06	22:14	09:09
14	17:43	07:54	19:35	09:46	20:58	09:40	23:25	09:38
15	18:32	09:00	20:48	10:30	22:09	10:11	DNR	10:10
16	19:30	10:03	22:00	11:08	23:18	10:40	00:35	10:46
17	20:35	11:01	23:10	11:40	DNR	11:08	01:45	11:28
18	21:46	11:50	DNR	12:09	00:26	11:37	02:51	12:17
19	22:57	12:31	00:18	12:37	01:35	12:09	03:51	13:12
20	DNR	13:06	01:25	13:05	02:44	12:47	04:44	14:12
21	00:08	13:37	02:33	13:35	03:52	13:30	05:28	15:14
22	01:17	14:06	03:43	14:09	04:57	14:21	06:05	16:16
23	02:26	14:34	04:52	14:48	05:55	15:18	06:36	17:16
24	03:34	15:02	06:01	15:35	06:46	16:20	07:02	18:14
25	04:44	15:34	07:05	16:28	07:28	17:23	07:26	19:10
26	05:56	16:11	08:02	17:28	08:03	18:24	07:49	20:06
27	07:07	16:53	08:50	18:31	08:33	19:24	08:11	21:02
28	08:15	17:44	09:30	19:34	08:59	20:21	08:34	21:58
29	09:18	18:41	10:03	20:35	09:22	21:17	08:59	22:57
30	10:12	19:42	10:31	21:33	09:44	22:13	09:27	23:58
31	10:57	20:45			10:07	23:09	10:01	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:41	01:01	11:22	01:51	13:50	02:29	15:05	01:57
2	11:31	02:05	12:31	02:40	15:01	02:59	16:17	02:27
3	12:31	03:05	13:44	03:23	16:12	03:28	17:31	03:00
4	13:40	04:00	14:58	03:59	17:26	03:58	18:45	03:40
5	14:54	04:48	16:11	04:32	18:41	04:30	19:56	04:27
6	16:10	05:29	17:25	05:02	19:56	05:07	20:58	05:22
7	17:25	06:05	18:39	05:32	21:10	05:50	21:51	06:24
8	18:39	06:36	19:54	06:03	22:17	06:42	22:34	07:30
9	19:53	07:06	21:09	06:37	23:15	07:40	23:09	08:36
10	21:06	07:36	22:23	07:17	DNR	08:44	23:39	09:39
11	22:19	08:08	23:32	08:03	00:02	09:48	DNR	10:39
12	23:32	08:44	DNR	08:56	00:40	10:52	00:04	11:37
13	DNR	09:25	00:33	09:56	01:12	11:52	00:27	12:33
14	00:42	10:12	01:25	10:58	01:39	12:51	00:50	13:28
15	01:46	11:06	02:07	12:01	02:03	13:47	01:12	14:25
16	02:41	12:06	02:41	13:02	02:25	14:42	01:37	15:23
17	03:28	13:07	03:11	14:01	02:47	15:38	02:04	16:23
18	04:07	14:09	03:36	14:59	03:11	16:35	02:36	17:26
19	04:39	15:10	03:59	15:54	03:36	17:35	03:15	18:30
20	05:07	16:08	04:21	16:50	04:05	18:36	04:02	19:31
21	05:31	17:05	04:44	17:46	04:39	19:40	04:58	20:27
22	05:54	18:00	05:07	18:44	05:20	20:42	06:02	21:16
23	06:16	18:56	05:34	19:44	06:10	21:41	07:11	21:58
24	06:39	19:52	06:04	20:46	07:08	22:34	08:22	22:33
25	07:03	20:51	06:40	21:48	08:13	23:19	09:32	23:03
26	07:30	21:51	07:23	22:49	09:21	23:57	10:40	23:32
27	08:01	22:53	08:14	23:46	10:30	DNS	11:48	23:59
28	08:39	23:55	09:14	DNS	11:39	00:31	12:55	DNS
29	09:24	DNS	10:19	00:36	12:47	01:01	14:04	00:28
30	10:19	00:55	11:29	01:20	13:56	01:29	15:15	00:59
31			12:39	01:57			16:27	01:35

Note: DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:35	20:07	07:55	20:44	06:38	19:12	08:43	19:33
2	06:47	20:56	09:01	21:18	07:46	19:47	09:50	20:19
3	07:58	21:37	10:05	21:52	08:52	20:22	10:55	21:10
4	09:07	22:14	11:09	22:27	09:57	21:00	11:55	22:04
5	10:12	22:47	12:12	23:04	11:03	21:42	12:49	23:02
6	11:14	23:19	13:14	23:46	12:07	22:28	13:36	DNS
7	12:15	23:52	14:16	DNS	13:08	23:19	14:17	00:00
8	13:17	DNS	15:15	00:33	14:05	DNS	14:52	00:57
9	14:18	00:27	16:09	01:25	14:55	00:14	15:23	01:52
10	15:20	01:05	16:57	02:20	15:39	01:11	15:51	02:46
11	16:21	01:48	17:39	03:17	16:17	02:08	16:18	03:38
12	17:19	02:36	18:16	04:14	16:50	03:04	16:45	04:30
13	18:12	03:29	18:48	05:10	17:20	03:59	17:12	05:22
14	18:59	04:26	19:17	06:04	17:48	04:52	17:42	06:16
15	19:39	05:23	19:45	06:56	18:15	05:44	18:15	07:12
16	20:15	06:21	20:11	07:48	18:42	06:35	18:54	08:11
17	20:46	07:16	20:38	08:40	19:09	07:28	19:38	09:13
18	21:15	08:09	21:06	09:32	19:40	08:22	20:30	10:15
19	21:42	09:01	21:38	10:27	20:14	09:18	21:30	11:16
20	22:08	09:53	22:14	11:24	20:54	10:18	22:35	12:12
21	22:36	10:45	22:56	12:25	21:41	11:19	23:42	13:02
22	23:06	11:38	23:47	13:28	22:35	12:21	DNR	13:46
23	23:39	12:35	DNR	14:32	23:37	13:21	00:50	14:25
24	DNR	13:35	00:47	15:32	DNR	14:17	01:56	15:01
25	00:19	14:39	01:54	16:27	00:45	15:06	03:02	15:35
26	01:06	15:45	03:06	17:16	01:55	15:50	04:07	16:09
27	02:03	16:50	04:18	17:59	03:05	16:29	05:13	16:45
28	03:08	17:50	05:29	18:37	04:14	17:05	06:20	17:24
29	04:20	18:43			05:21	17:40	07:28	18:08
30	05:34	19:28			06:28	18:15	08:35	18:57
31	06:46	20:08			07:35	18:52		

	MAY		JUNE		JULY		AUGUST	
1	09:40	19:51	10:47	21:33	10:21	22:05	10:10	23:26
2	10:38	20:49	11:22	22:28	10:48	22:57	10:40	DNS
3	11:29	21:49	11:52	23:22	11:14	23:48	11:15	00:22
4	12:13	22:47	12:20	DNS	11:41	DNS	11:55	01:21
5	12:51	23:44	12:47	00:14	12:10	00:41	12:43	02:23
6	13:23	DNS	13:14	01:05	12:43	01:36	13:40	03:25
7	13:53	00:38	13:42	01:58	13:21	02:34	14:45	04:26
8	14:20	01:30	14:13	02:52	14:05	03:36	15:55	05:22
9	14:47	02:22	14:48	03:49	14:58	04:40	17:07	06:12
10	15:14	03:14	15:28	04:50	16:00	05:43	18:17	06:55
11	15:43	04:08	16:17	05:53	17:07	06:42	19:25	07:33
12	16:15	05:03	17:13	06:57	18:18	07:35	20:32	08:09
13	16:52	06:02	18:17	07:58	19:28	08:21	21:37	08:43
14	17:35	07:03	19:25	08:54	20:36	09:01	22:43	09:18
15	18:26	08:07	20:33	09:43	21:41	09:37	23:48	09:55
16	19:24	09:09	21:41	10:25	22:44	10:11	DNR	10:35
17	20:28	10:07	22:45	11:03	23:48	10:44	00:54	11:21
18	21:35	11:00	23:48	11:37	DNR	11:18	01:57	12:11
19	22:42	11:45	DNR	12:09	00:51	11:55	02:57	13:07
20	23:47	12:25	00:51	12:42	01:56	12:36	03:51	14:05
21	DNR	13:01	01:54	13:17	03:00	13:23	04:38	15:04
22	00:52	13:35	02:58	13:55	04:03	14:15	05:18	16:02
23	01:55	14:08	04:03	14:39	05:01	15:12	05:53	16:58
24	02:58	14:42	05:08	15:28	05:54	16:12	06:24	17:52
25	04:03	15:18	06:11	16:23	06:39	17:11	06:52	18:44
26	05:09	15:59	07:08	17:22	07:18	18:09	07:19	19:35
27	06:16	16:45	07:59	18:22	07:52	19:05	07:45	20:27
28	07:22	17:38	08:42	19:21	08:22	19:58	08:12	21:19
29	08:24	18:35	09:19	20:18	08:49	20:50	08:41	22:13
30	09:19	19:35	09:52	21:13	09:16	21:41	09:13	23:10
31	10:06	20:35			09:42	22:32	09:50	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:34	00:10	11:15	00:57	13:27	01:51	14:28	01:32
2	11:26	01:11	12:21	01:49	14:32	02:26	15:35	02:07
3	12:25	02:11	13:29	02:36	15:38	03:00	16:43	02:45
4	13:31	03:08	14:38	03:17	16:46	03:35	17:53	03:29
5	14:41	03:59	15:46	03:55	17:56	04:12	19:01	04:19
6	15:52	04:45	16:54	04:31	19:06	04:54	20:04	05:16
7	17:02	05:26	18:02	05:06	20:17	05:41	20:59	06:18
8	18:11	06:03	19:11	05:43	21:22	06:35	21:46	07:21
9	19:18	06:38	20:21	06:22	22:21	07:34	22:25	08:24
10	20:26	07:14	21:31	07:06	23:11	08:36	22:59	09:23
11	21:34	07:51	22:38	07:56	23:53	09:38	23:28	10:19
12	22:42	08:31	23:39	08:51	DNR	10:38	23:56	11:12
13	23:49	09:16	DNR	09:50	00:29	11:35	DNR	12:04
14	DNR	10:06	00:32	10:50	01:00	12:28	00:22	12:55
15	00:51	11:01	01:17	11:50	01:28	13:20	00:49	13:47
16	01:47	11:59	01:56	12:47	01:55	14:12	01:18	14:41
17	02:37	12:59	02:29	13:42	02:22	15:03	01:49	15:37
18	03:19	13:57	02:59	14:35	02:49	15:56	02:25	16:36
19	03:55	14:53	03:26	15:27	03:18	16:51	03:07	17:37
20	04:27	15:47	03:53	16:18	03:51	17:49	03:56	18:37
21	04:56	16:40	04:19	17:10	04:29	18:48	04:52	19:34
22	05:23	17:31	04:47	18:03	05:13	19:49	05:55	20:26
23	05:49	18:22	05:17	18:59	06:04	20:47	07:00	21:11
24	06:16	19:15	05:51	19:57	07:02	21:41	08:06	21:51
25	06:44	20:08	06:30	20:56	08:04	22:30	09:11	22:27
26	07:15	21:04	07:16	21:55	09:09	23:13	10:15	23:00
27	07:50	22:02	08:08	22:52	10:14	23:51	11:17	23:33
28	08:31	23:02	09:07	23:44	11:18	DNS	12:20	DNS
29	09:18	DNS	10:10	DNS	12:21	00:25	13:24	00:06
30	10:13	00:01	11:16	00:31	13:24	00:59	14:30	00:42
31			12:22	01:13			15:37	01:23

CANBERRA (EST) MOON RISE AND SET DARWIN (CST)

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:27	20:45	08:05	21:03	06:52	19:28	09:16	19:31
2	06:43	21:28	09:17	21:32	08:05	19:57	10:27	20:12
3	08:00	22:04	10:27	22:00	09:16	20:28	11:36	21:01
4	09:14	22:36	11:36	22:30	10:28	21:00	12:37	21:55
5	10:24	23:04	12:44	23:03	11:38	21:38	13:31	22:54
6	11:32	23:31	13:51	23:41	12:46	22:20	14:15	23:54
7	12:39	23:59	14:56	DNS	13:50	23:10	14:52	DNS
8	13:45	DNS	15:56	00:25	14:46	DNS	15:23	00:55
9	14:52	00:29	16:50	01:15	15:35	00:04	15:50	01:55
10	15:58	01:02	17:36	02:11	16:16	01:03	16:14	02:53
11	17:01	01:42	18:15	03:10	16:51	02:04	16:36	03:49
12	18:01	02:28	18:48	04:11	17:20	03:04	16:59	04:46
13	18:53	03:20	19:16	05:11	17:46	04:03	17:22	05:43
14	19:37	04:18	19:41	06:09	18:09	05:00	17:47	06:41
15	20:14	05:18	20:04	07:06	18:31	05:57	18:16	07:42
16	20:46	06:19	20:26	08:02	18:54	06:53	18:50	08:46
17	21:13	07:18	20:49	08:59	19:17	07:50	19:31	09:51
18	21:37	08:16	21:13	09:56	19:43	08:49	20:21	10:56
19	22:00	09:13	21:40	10:55	20:13	09:50	21:21	11:57
20	22:22	10:09	22:12	11:57	20:49	10:54	22:27	12:52
21	22:45	11:05	22:50	13:02	21:32	11:59	23:39	13:39
22	23:10	12:04	23:38	14:09	22:26	13:03	DNR	14:18
23	23:40	13:05	DNR	15:13	23:29	14:03	00:51	14:52
24	DNR	14:10	00:37	16:13	DNR	14:56	02:04	15:23
25	00:15	15:17	01:46	17:05	00:39	15:42	03:15	15:51
26	00:59	16:26	03:02	17:49	01:54	16:20	04:26	16:20
27	01:53	17:31	04:20	18:26	03:09	16:54	05:38	16:50
28	03:00	18:29	05:37	18:59	04:23	17:24	06:50	17:24
29	04:14	19:18			05:37	17:53	08:03	18:03
30	05:33	19:58			06:50	18:23	09:15	18:49
31	06:51	20:33			08:03	18:55		

	MAY		JUNE		JULY		AUGUST	
1	10:21	19:42	11:21	21:32	10:44	22:16	10:17	23:53
2	11:20	20:40	11:52	22:32	11:07	23:12	10:43	DNS
3	12:09	21:42	12:18	23:30	11:29	DNS	11:13	00:54
4	12:50	22:44	12:42	DNS	11:51	00:08	11:50	01:57
5	13:23	23:44	13:04	00:26	12:16	01:05	12:35	03:02
6	13:52	DNS	13:27	01:22	12:44	02:05	13:31	04:07
7	14:17	00:43	13:50	02:19	13:17	03:08	14:37	05:07
8	14:40	01:40	14:16	03:18	13:58	04:14	15:50	06:01
9	15:02	02:36	14:47	04:20	14:49	05:21	17:06	06:46
10	15:25	03:33	15:24	05:25	15:51	06:25	18:23	07:24
11	15:49	04:31	16:09	06:32	17:01	07:23	19:37	07:57
12	16:17	05:32	17:04	07:38	18:15	08:12	20:49	08:27
13	16:49	06:35	18:08	08:40	19:30	08:53	22:00	08:55
14	17:29	07:41	19:19	09:33	20:44	09:28	23:11	09:25
15	18:17	08:47	20:32	10:18	21:54	09:58	DNR	09:56
16	19:14	09:51	21:45	10:55	23:04	10:27	00:22	10:32
17	20:20	10:48	22:55	11:27	DNR	10:54	01:32	11:14
18	21:30	11:38	DNR	11:56	00:12	11:23	02:38	12:02
19	22:42	12:19	00:04	12:24	01:21	11:56	03:39	12:57
20	23:53	12:54	01:11	12:51	02:31	12:32	04:32	13:57
21	DNR	13:25	02:20	13:21	03:39	13:16	05:16	14:59
22	01:03	13:53	03:29	13:54	04:44	14:06	05:53	16:01
23	02:11	14:20	04:39	14:34	05:43	15:03	06:24	17:02
24	03:21	14:49	05:48	15:20	06:34	16:05	06:50	18:00
25	04:31	15:20	06:52	16:13	07:16	17:08	07:14	18:57
26	05:42	15:56	07:50	17:13	07:51	18:10	07:36	19:52
27	06:54	16:39	08:38	18:16	08:21	19:09	07:58	20:48
28	08:03	17:29	09:18	19:19	08:46	20:07	08:21	21:45
29	09:05	18:25	09:51	20:20	09:10	21:03	08:45	22:44
30	09:59	19:27	10:19	21:19	09:32	21:59	09:13	23:45
31	10:44	20:30			09:54	22:55	09:46	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:27	00:49	11:07	01:39	13:36	02:17	14:52	01:44
2	11:16	01:52	12:16	02:28	14:47	02:47	16:03	02:13
3	12:16	02:53	13:29	03:10	15:58	03:15	17:18	02:46
4	13:24	03:48	14:43	03:47	17:12	03:45	18:32	03:25
5	14:38	04:36	15:57	04:19	18:27	04:16	19:43	04:12
6	15:55	05:17	17:11	04:49	19:43	04:53	20:46	05:07
7	17:10	05:52	18:25	05:18	20:57	05:36	21:39	06:09
8	18:25	06:23	19:40	05:49	22:04	06:27	22:22	07:15
9	19:39	06:53	20:56	06:23	23:02	07:25	22:57	08:21
10	20:52	07:23	22:10	07:02	23:49	08:28	23:26	09:24
11	22:06	07:54	23:20	07:48	DNR	09:33	23:52	10:25
12	23:19	08:30	DNR	08:41	00:28	10:37	DNR	11:23
13	DNR	09:10	00:21	09:40	00:59	11:38	00:15	12:19
14	00:29	09:57	01:12	10:43	01:26	12:36	00:37	13:15
15	01:33	10:51	01:55	11:46	01:50	13:33	00:59	14:11
16	02:29	11:50	02:29	12:48	02:12	14:29	01:23	15:09
17	03:16	12:52	02:58	13:47	02:34	15:25	01:51	16:10
18	03:55	13:54	03:23	14:44	02:57	16:22	02:22	17:13
19	04:27	14:55	03:47	15:41	03:23	17:21	03:01	18:17
20	04:55	15:54	04:09	16:36	03:51	18:23	03:47	19:19
21	05:19	16:51	04:31	17:33	04:25	19:27	04:43	20:15
22	05:41	17:47	04:54	18:31	05:06	20:29	05:47	21:04
23	06:03	18:42	05:20	19:31	05:55	21:29	06:56	21:45
24	06:26	19:39	05:50	20:33	06:53	22:21	08:07	22:20
25	06:49	20:37	06:25	21:36	07:57	23:07	09:17	22:51
26	07:16	21:38	07:08	22:37	09:06	23:45	10:26	23:19
27	07:47	22:40	07:59	23:34	10:15	DNS	11:34	23:46
28	08:24	23:42	08:58	DNS	11:24	00:18	12:42	DNS
29	09:10	DNS	10:04	00:24	12:33	00:48	13:51	00:14
30	10:04	00:43	11:14	01:07	13:42	01:16	15:02	00:45
31			12:25	01:44			16:14	01:21

Note: DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	07:15	20:36	09:07	21:41	07:46	20:14	09:19	21:05
2	08:22	21:31	10:04	22:24	08:44	20:57	10:19	21:57
3	09:25	22:20	10:59	23:06	09:41	21:42	11:19	22:51
4	10:24	23:05	11:54	23:49	10:38	22:28	12:18	23:47
5	11:20	23:47	12:49	DNS	11:36	23:16	13:12	DNS
6	12:14	DNS	13:45	00:34	12:34	DNS	14:02	00:43
7	13:06	00:28	14:42	01:23	13:32	00:08	14:48	01:37
8	14:00	01:09	15:38	02:14	14:27	01:01	15:29	02:28
9	14:54	01:52	16:31	03:07	15:19	01:56	16:06	03:16
10	15:50	02:37	17:22	04:01	16:07	02:50	16:41	04:03
11	16:46	03:26	18:08	04:55	16:50	03:42	17:15	04:47
12	17:42	04:17	18:51	05:46	17:30	04:32	17:49	05:32
13	18:35	05:12	19:29	06:36	18:06	05:20	18:24	06:17
14	19:25	06:06	20:05	07:23	18:41	06:06	19:02	07:03
15	20:10	07:00	20:40	08:08	19:15	06:50	19:42	07:53
16	20:52	07:51	21:13	08:53	19:49	07:35	20:27	08:45
17	21:30	08:40	21:47	09:37	20:24	08:20	21:17	09:41
18	22:05	09:26	22:23	10:22	21:02	09:07	22:13	10:39
19	22:39	10:11	23:02	11:10	21:43	09:56	23:12	11:38
20	23:13	10:55	23:45	12:00	22:29	10:49	DNR	12:36
21	23:47	11:40	DNR	12:55	23:21	11:46	00:14	13:31
22	DNR	12:26	00:34	13:53	DNR	12:45	01:15	14:22
23	00:25	13:15	01:29	14:55	00:18	13:44	02:15	15:09
24	01:06	14:09	02:30	15:56	01:20	14:43	03:13	15:53
25	01:52	15:07	03:35	16:56	02:23	15:38	04:10	16:36
26	02:45	16:09	04:41	17:51	03:26	16:29	05:06	17:19
27	03:45	17:13	05:45	18:42	04:27	17:16	06:02	18:04
28	04:51	18:16	06:47	19:29	05:27	18:02	07:01	18:51
29	05:58	19:15			06:25	18:45	08:01	19:43
30	07:05	20:08			07:22	19:30	09:02	20:37
31	08:08	20:56			08:20	20:16		

	MAY		JUNE		JULY		AUGUST	
1	10:03	21:34	11:19	23:02	11:10	23:15	11:26	DNS
2	11:01	22:31	12:00	23:50	11:44	00:00	12:03	00:10
3	11:54	23:27	12:38	DNS	12:18	DNS	12:45	00:59
4	12:42	DNS	13:13	00:37	12:52	00:44	13:31	01:52
5	13:25	00:20	13:46	01:21	13:29	01:29	14:24	02:49
6	14:04	01:10	14:20	02:06	14:08	02:18	15:23	03:49
7	14:40	01:57	14:56	02:51	14:53	03:09	16:27	04:50
8	15:15	02:43	15:34	03:38	15:43	04:05	17:32	05:49
9	15:48	03:27	16:16	04:28	16:40	05:05	18:36	06:45
10	16:23	04:12	17:03	05:22	17:42	06:06	19:37	07:36
11	16:59	04:58	17:57	06:20	18:47	07:07	20:36	08:23
12	17:39	05:46	18:56	07:21	19:51	08:05	21:33	09:08
13	18:23	06:38	19:58	08:22	20:53	08:58	22:29	09:51
14	19:12	07:33	21:02	09:21	21:52	09:46	23:26	10:34
15	20:07	08:32	22:04	10:15	22:48	10:31	DNR	11:19
16	21:06	09:32	23:02	11:05	23:42	11:13	00:24	12:07
17	22:08	10:31	23:58	11:50	DNR	11:55	01:23	12:59
18	23:10	11:28	DNR	12:33	00:37	12:37	02:22	13:53
19	DNR	12:19	00:53	13:14	01:32	13:22	03:20	14:49
20	00:10	13:07	01:46	13:55	02:29	14:10	04:14	15:46
21	01:07	13:51	02:41	14:38	03:28	15:03	05:05	16:40
22	02:02	14:33	03:37	15:24	04:27	15:58	05:50	17:32
23	02:57	15:14	04:35	16:14	05:24	16:55	06:31	18:21
24	03:51	15:57	05:35	17:08	06:18	17:51	07:09	19:07
25	04:47	16:42	06:34	18:05	07:07	18:45	07:44	19:52
26	05:45	17:31	07:32	19:03	07:52	19:36	08:18	20:36
27	06:46	18:23	08:25	19:59	08:32	20:25	08:51	21:20
28	07:47	19:19	09:13	20:53	09:09	21:11	09:25	22:05
29	08:46	20:17	09:56	21:43	09:44	21:55	10:01	22:53
30	09:43	21:15	10:35	22:30	10:17	22:39	10:41	23:43
31	10:34	22:10			10:51	23:23	11:24	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	12:13	00:37	12:56	01:21	14:42	02:36	15:20	02:40
2	13:08	01:35	13:57	02:16	15:38	03:20	16:17	03:24
3	14:08	02:34	14:58	03:09	16:35	04:03	17:18	04:11
4	15:11	03:32	15:58	03:58	17:34	04:47	18:21	05:02
5	16:15	04:29	16:57	04:44	18:34	05:33	19:25	05:59
6	17:17	05:21	17:55	05:29	19:38	06:24	20:27	06:59
7	18:18	06:11	18:54	06:14	20:42	07:18	21:25	08:00
8	19:17	06:57	19:54	07:00	21:45	08:17	22:16	09:00
9	20:15	07:41	20:56	07:48	22:45	09:17	23:01	09:56
10	21:13	08:26	21:59	08:40	23:38	10:17	23:41	10:48
11	22:13	09:12	23:02	09:36	DNR	11:14	DNR	11:37
12	23:13	10:01	DNR	10:34	00:25	12:08	00:18	12:23
13	DNR	10:52	00:02	11:32	01:07	12:57	00:52	13:07
14	00:14	11:47	00:57	12:29	01:45	13:44	01:26	13:51
15	01:14	12:44	01:46	13:24	02:20	14:28	02:00	14:36
16	02:10	13:41	02:30	14:14	02:54	15:12	02:35	15:23
17	03:02	14:36	03:10	15:02	03:28	15:57	03:14	16:13
18	03:49	15:29	03:46	15:48	04:02	16:42	03:56	17:06
19	04:31	16:18	04:21	16:32	04:39	17:30	04:44	18:02
20	05:10	17:05	04:54	17:16	05:19	18:22	05:37	19:01
21	05:45	17:50	05:28	18:01	06:03	19:16	06:34	19:58
22	06:19	18:34	06:03	18:47	06:52	20:13	07:35	20:54
23	06:53	19:18	06:40	19:36	07:46	21:10	08:35	21:45
24	07:26	20:03	07:21	20:28	08:44	22:06	09:35	22:32
25	08:02	20:50	08:06	21:22	09:43	22:59	10:31	23:16
26	08:40	21:39	08:56	22:18	10:42	23:48	11:26	23:58
27	09:22	22:31	09:51	23:15	11:40	DNS	12:20	DNS
28	10:08	23:27	10:49	DNS	12:35	00:34	13:14	00:39
29	11:00	DNS	11:48	00:10	13:30	01:17	14:09	01:21
30	11:56	00:24	12:47	01:02	14:24	01:58	15:07	02:05
31			13:45	01:51			16:07	02:53

HOBART (EST) MOON RISE AND SET MELBOURNE (EST)

HOBART (EST)

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:06	21:18	08:06	21:14	06:56	19:36	09:44	19:17
2	06:27	21:56	09:25	21:36	08:16	19:59	11:02	19:53
3	07:50	22:26	10:42	21:58	09:35	20:23	12:14	20:37
4	09:11	22:50	11:57	22:22	10:52	20:49	13:17	21:31
5	10:28	23:12	13:11	22:50	12:09	21:21	14:10	22:31
6	11:43	23:34	14:24	23:22	13:22	21:59	14:51	23:36
7	12:56	23:55	15:33	DNS	14:29	22:46	15:23	DNS
8	14:08	DNS	16:36	00:03	15:26	23:41	15:49	00:41
9	15:21	00:19	17:29	00:51	16:13	DNS	16:11	01:46
10	16:32	00:48	18:13	01:48	16:51	00:42	16:29	02:49
11	17:39	01:22	18:48	02:50	17:20	01:46	16:47	03:52
12	18:40	02:05	19:16	03:55	17:44	02:52	17:04	04:53
13	19:31	02:56	19:39	05:01	18:05	03:56	17:22	05:56
14	20:13	03:56	19:59	06:04	18:23	04:59	17:42	07:00
15	20:45	05:00	20:16	07:07	18:40	06:01	18:05	08:07
16	21:12	06:05	20:33	08:08	18:57	07:03	18:34	09:16
17	21:34	07:10	20:51	09:10	19:15	08:05	19:10	10:27
18	21:53	08:13	21:09	10:13	19:36	09:10	19:58	11:35
19	22:10	09:15	21:31	11:18	20:00	10:17	20:57	12:37
20	22:27	10:16	21:57	12:26	20:31	11:26	22:07	13:30
21	22:45	11:18	22:31	13:36	21:11	12:36	23:23	14:12
22	23:05	12:22	23:16	14:47	22:02	13:43	DNR	14:46
23	23:29	13:29	DNR	15:53	23:06	14:43	00:42	15:13
24	23:59	14:40	00:13	16:52	DNR	15:33	02:01	15:37
25	DNR	15:53	01:24	17:39	00:20	16:13	03:19	15:59
26	00:38	17:05	02:45	18:17	01:40	16:45	04:37	16:22
27	01:30	18:11	04:10	18:48	03:02	17:12	05:56	16:45
28	02:37	19:06	05:34	19:13	04:24	17:36	07:15	17:13
29	03:55	19:49			05:44	17:58	08:35	17:46
30	05:20	20:23			07:04	18:21	09:51	18:27
31	06:44	20:50			08:24	18:47		

	MAY		JUNE		JULY		AUGUST	
1	11:01	19:18	11:51	21:19	11:00	22:18	10:15	DNS
2	11:59	20:17	12:17	22:25	11:18	23:19	10:35	00:15
3	12:46	21:21	12:38	23:28	11:35	DNS	11:00	01:21
4	13:23	22:28	12:56	DNS	11:52	00:21	11:32	02:30
5	13:51	23:34	13:14	00:30	12:11	01:24	12:13	03:40
6	14:14	DNS	13:31	01:31	12:34	02:29	13:07	04:47
7	14:34	00:38	13:49	02:34	13:02	03:38	14:14	05:46
8	14:52	01:41	14:10	03:39	13:39	04:49	15:32	06:36
9	15:09	02:42	14:35	04:46	14:26	05:59	16:55	07:16
10	15:27	03:44	15:06	05:57	15:27	07:04	18:18	07:47
11	15:46	04:48	15:47	07:09	16:40	08:00	19:39	08:13
12	16:08	05:54	16:40	08:18	18:00	08:45	20:58	08:37
13	16:35	07:03	17:46	09:19	19:22	09:20	22:16	08:59
14	17:10	08:14	19:01	10:09	20:42	09:48	23:34	09:22
15	17:54	09:25	20:20	10:49	21:59	10:12	DNR	09:47
16	18:51	10:30	21:38	11:20	23:15	10:34	00:51	10:17
17	19:58	11:27	22:55	11:46	DNR	10:56	02:06	10:54
18	21:13	12:12	DNR	12:08	00:30	11:19	03:17	11:39
19	22:31	12:48	00:11	12:29	01:46	11:45	04:19	12:33
20	23:49	13:17	01:25	12:51	03:01	12:16	05:10	13:35
21	DNR	13:41	02:40	13:15	04:15	12:55	05:51	14:41
22	01:05	14:03	03:55	13:42	05:23	13:43	06:23	15:48
23	02:20	14:25	05:11	14:16	06:23	14:40	06:49	16:54
24	03:36	14:47	06:25	14:58	07:11	15:44	07:10	17:58
25	04:53	15:12	07:32	15:50	07:50	16:51	07:28	19:00
26	06:11	15:42	08:29	16:50	08:20	17:59	07:46	20:01
27	07:28	16:19	09:14	17:57	08:44	19:04	08:02	21:02
28	08:41	17:06	09:50	19:04	09:04	20:07	08:20	22:05
29	09:45	18:02	10:18	20:11	09:22	21:09	08:39	23:09
30	10:38	19:05	10:41	21:16	09:39	22:10	09:02	DNS
31	11:19	20:12			09:56	23:11	09:30	00:16

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:06	01:24	10:45	02:17	13:34	02:37	15:08	01:47
2	10:53	02:31	11:58	03:03	14:52	03:00	16:27	02:10
3	11:52	03:33	13:17	03:40	16:11	03:22	17:48	02:37
4	13:04	04:26	14:38	04:10	17:31	03:45	19:07	03:09
5	14:23	05:09	15:59	04:36	18:54	04:10	20:22	03:51
6	15:46	05:43	17:20	04:59	20:16	04:40	21:25	04:43
7	17:09	06:12	18:41	05:22	21:35	05:17	22:16	05:46
8	18:31	06:37	20:03	05:46	22:44	06:04	22:55	06:55
9	19:51	07:00	21:26	06:14	23:41	07:01	23:24	08:06
10	21:12	07:23	22:46	06:46	DNR	08:06	23:48	09:15
11	22:33	07:48	23:59	07:27	00:25	09:15	DNR	10:21
12	23:52	08:17	DNR	08:17	00:58	10:24	00:08	11:24
13	DNR	08:52	01:01	09:17	01:24	11:30	00:26	12:26
14	01:07	09:35	01:50	10:22	01:46	12:34	00:43	13:27
15	02:13	10:27	02:28	11:30	02:05	13:36	01:00	14:29
16	03:08	11:27	02:58	12:37	02:22	14:37	01:19	15:33
17	03:52	12:33	03:21	13:42	02:39	15:39	01:41	16:39
18	04:27	13:40	03:41	14:44	02:57	16:42	02:08	17:47
19	04:54	14:46	03:59	15:46	03:16	17:47	02:42	18:55
20	05:16	15:50	04:16	16:47	03:40	18:54	03:25	19:58
21	05:35	16:52	04:33	17:49	04:09	20:02	04:20	20:53
22	05:53	17:54	04:51	18:52	04:45	21:08	05:25	21:38
23	06:09	18:55	05:12	19:58	05:32	22:08	06:39	22:14
24	06:26	19:57	05:37	21:05	06:30	22:59	07:55	22:43
25	06:45	21:01	06:07	22:12	07:37	23:40	09:12	23:08
26	07:07	22:07	06:46	23:16	08:50	DNS	10:27	23:30
27	07:32	23:14	07:35	DNS	10:06	00:13	11:42	23:51
28	08:05	DNS	08:35	00:13	11:21	00:40	12:56	DNS
29	08:47	00:20	09:45	01:00	12:36	01:03	14:12	00:13
30	09:40	01:23	11:00	01:39	13:51	01:25	15:30	00:38
31			12:17	02:10			16:48	01:07

Note: DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

MELBOURNE (EST)

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:35	21:10	08:21	21:21	07:08	19:45	09:39	19:41
2	06:53	21:52	09:35	21:47	08:23	20:12	10:53	20:21
3	08:12	22:26	10:46	22:14	09:37	20:40	12:02	21:08
4	09:28	22:55	11:57	22:42	10:50	21:11	13:04	22:02
5	10:40	23:21	13:07	23:13	12:02	21:47	13:57	23:01
6	11:50	23:46	14:16	23:50	13:12	22:28	14:41	DNS
7	12:59	DNS	15:22	DNS	14:17	23:17	15:16	00:03
8	14:07	00:12	16:23	00:32	15:14	DNS	15:46	01:06
9	15:16	00:40	17:17	01:22	16:02	00:12	16:11	02:07
10	16:23	01:12	18:02	02:18	16:42	01:11	16:33	03:06
11	17:28	01:50	18:40	03:19	17:15	02:13	16:54	04:05
12	18:28	02:35	19:11	04:21	17:42	03:15	17:14	05:03
13	19:19	03:27	19:38	05:22	18:06	04:15	17:36	06:02
14	20:03	04:25	20:01	06:22	18:28	05:14	18:00	07:02
15	20:39	05:27	20:22	07:21	18:49	06:13	18:27	08:05
16	21:08	06:29	20:43	08:19	19:09	07:11	18:59	09:10
17	21:34	07:30	21:04	09:17	19:31	08:10	19:39	10:17
18	21:56	08:30	21:26	10:16	19:55	09:10	20:29	11:23
19	22:17	09:28	21:51	11:17	20:23	10:13	21:28	12:25
20	22:38	10:26	22:22	12:21	20:58	11:19	22:36	13:18
21	23:00	11:24	22:59	13:28	21:40	12:25	23:49	14:04
22	23:23	12:24	23:46	14:35	22:33	13:30	DNR	14:41
23	23:51	13:27	DNR	15:41	23:36	14:30	01:03	15:13
24	DNR	14:34	00:44	16:40	DNR	15:22	02:18	15:42
25	00:24	15:43	01:54	17:31	00:48	16:06	03:31	16:08
26	01:07	16:53	03:11	18:12	02:04	16:43	04:44	16:35
27	02:01	17:58	04:31	18:47	03:22	17:14	05:58	17:03
28	03:07	18:55	05:51	19:18	04:38	17:42	07:13	17:35
29	04:23	19:42			05:54	18:09	08:28	18:12
30	05:44	20:21			07:09	18:37	09:41	18:57
31	07:03	20:53			08:24	19:07		

	MAY		JUNE		JULY		AUGUST	
1	10:48	19:49	11:45	21:43	11:03	22:31	10:31	DNS
2	11:47	20:48	12:14	22:44	11:24	23:29	10:55	00:15
3	12:35	21:50	12:39	23:44	11:45	DNS	11:24	01:17
4	13:15	22:54	13:01	DNS	12:06	00:27	11:59	02:22
5	13:47	23:56	13:22	00:42	12:29	01:26	12:43	03:29
6	14:13	DNS	13:42	01:40	12:55	02:28	13:38	04:34
7	14:37	00:56	14:04	02:39	13:27	03:32	14:44	05:34
8	14:58	01:55	14:29	03:39	14:07	04:40	15:59	06:26
9	15:19	02:53	14:58	04:43	14:57	05:48	17:18	07:10
10	15:40	03:51	15:33	05:50	15:58	06:52	18:36	07:46
11	16:02	04:51	16:17	06:59	17:09	07:49	19:52	08:17
12	16:28	05:53	17:11	08:05	18:25	08:37	21:07	08:44
13	16:59	06:59	18:16	09:07	19:42	09:16	22:20	09:11
14	17:37	08:06	19:28	09:59	20:58	09:49	23:33	09:38
15	18:24	09:14	20:43	10:42	22:11	10:17	DNR	10:08
16	19:22	10:18	21:58	11:18	23:22	10:43	00:46	10:42
17	20:28	11:15	23:10	11:48	DNR	11:09	01:57	11:22
18	21:40	12:03	DNR	12:14	00:33	11:36	03:05	12:10
19	22:53	12:43	00:21	12:40	01:44	12:07	04:06	13:04
20	DNR	13:16	01:31	13:06	02:55	12:42	04:58	14:05
21	00:06	13:44	02:41	13:33	04:05	13:24	05:41	15:08
22	01:18	14:11	03:52	14:05	05:11	14:13	06:17	16:12
23	02:29	14:36	05:04	14:43	06:10	15:11	06:46	17:14
24	03:40	15:03	06:14	15:28	07:00	16:13	07:11	18:14
25	04:52	15:32	07:20	16:21	07:41	17:17	07:33	19:12
26	06:06	16:06	08:17	17:21	08:15	18:21	07:53	20:10
27	07:19	16:47	09:04	18:25	08:42	19:22	08:14	21:07
28	08:29	17:36	09:43	19:29	09:06	20:22	08:35	22:06
29	09:33	18:33	10:14	20:32	09:28	21:20	08:58	23:07
30	10:26	19:35	10:40	21:33	09:48	22:17	09:24	DNS
31	11:10	20:39			10:09	23:15	09:56	00:10

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:35	01:14	11:15	02:05	13:50	02:38	15:12	01:59
2	11:24	02:19	12:25	02:53	15:03	03:05	16:26	02:26
3	12:23	03:20	13:40	03:34	16:17	03:32	17:42	02:58
4	13:33	04:14	14:56	04:08	17:33	03:59	18:58	03:35
5	14:48	05:01	16:12	04:39	18:50	04:29	20:10	04:20
6	16:07	05:40	17:28	05:07	20:08	05:03	21:13	05:14
7	17:25	06:13	18:45	05:34	21:24	05:45	22:05	06:17
8	18:42	06:42	20:02	06:03	22:32	06:34	22:47	07:23
9	19:58	07:10	21:20	06:35	23:29	07:32	23:20	08:31
10	21:13	07:37	22:36	07:12	DNR	08:36	23:48	09:36
11	22:29	08:07	23:47	07:56	00:15	09:42	DNR	10:38
12	23:44	08:40	DNR	08:49	00:52	10:48	00:11	11:38
13	DNR	09:19	00:48	09:48	01:22	11:50	00:33	12:36
14	00:55	10:05	01:39	10:51	01:47	12:50	00:53	13:33
15	02:00	10:58	02:20	11:56	02:09	13:49	01:14	14:31
16	02:56	11:58	02:53	12:59	02:30	14:46	01:37	15:32
17	03:42	13:01	03:20	14:00	02:50	15:44	02:02	16:34
18	04:19	14:05	03:44	14:59	03:11	16:43	02:32	17:39
19	04:50	15:07	04:05	15:57	03:35	17:44	03:09	18:44
20	05:16	16:07	04:25	16:54	04:02	18:48	03:55	19:46
21	05:38	17:06	04:46	17:53	04:34	19:53	04:50	20:42
22	05:59	18:03	05:08	18:52	05:14	20:56	05:55	21:29
23	06:20	19:01	05:32	19:54	06:03	21:56	07:05	22:09
24	06:40	19:59	06:00	20:58	07:00	22:48	08:18	22:42
25	07:02	20:59	06:34	22:02	08:06	23:32	09:30	23:11
26	07:27	22:02	07:16	23:04	09:16	DNS	10:41	23:37
27	07:57	23:05	08:06	DNS	10:27	00:08	11:51	DNS
28	08:33	DNS	09:06	00:00	11:38	00:39	13:01	00:02
29	09:17	00:09	10:13	00:50	12:49	01:07	14:12	00:28
30	10:11	01:10	11:24	01:32	14:00	01:33	15:25	00:57
31			12:37	02:07			16:39	01:31

PERTH (WST) MOON RISE AND SET SYDNEY (EST)

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:58	20:53	08:28	21:18	07:13	19:44	09:28	19:56
2	07:12	21:38	09:37	21:49	08:23	20:16	10:37	20:40
3	08:26	22:16	10:44	22:19	09:32	20:49	11:44	21:30
4	09:37	22:49	11:50	22:52	10:41	21:24	12:44	22:25
5	10:45	23:19	12:56	23:27	11:49	22:04	13:37	23:23
6	11:51	23:49	14:01	DNS	12:55	22:49	14:22	DNS
7	12:55	DNS	15:04	00:08	13:57	23:39	15:00	00:23
8	13:59	00:19	16:03	00:53	14:53	DNS	15:32	01:22
9	15:03	00:51	16:56	01:45	15:42	00:34	16:00	02:19
10	16:07	01:28	17:43	02:41	16:23	01:32	16:26	03:15
11	17:09	02:09	18:23	03:39	16:59	02:31	16:51	04:10
12	18:07	02:57	18:57	04:38	17:30	03:30	17:15	05:04
13	18:59	03:50	19:26	05:36	17:57	04:26	17:40	05:59
14	19:44	04:47	19:53	06:32	18:22	05:22	18:08	06:56
15	20:22	05:46	20:18	07:27	18:46	06:16	18:39	07:55
16	20:55	06:45	20:42	08:21	19:11	07:10	19:15	08:57
17	21:24	07:43	21:06	09:15	19:36	08:06	19:59	10:00
18	21:50	08:39	21:33	10:11	20:05	09:02	20:51	11:04
19	22:14	09:33	22:02	11:08	20:37	10:02	21:51	12:04
20	22:38	10:27	22:36	12:09	21:15	11:04	22:57	12:59
21	23:04	11:22	23:18	13:12	22:01	12:07	DNR	13:47
22	23:31	12:18	DNR	14:17	22:56	13:10	00:07	14:28
23	DNR	13:17	00:08	15:21	23:59	14:10	01:18	15:04
24	00:03	14:20	01:08	16:20	DNR	15:04	02:27	15:36
25	00:41	15:27	02:17	17:13	01:09	15:50	03:36	16:07
26	01:27	16:34	03:31	17:58	02:21	16:31	04:44	16:38
27	02:24	17:39	04:46	18:38	03:34	17:06	05:53	17:11
28	03:30	18:37	06:01	19:12	04:46	17:39	07:04	17:48
29	04:44	19:27			05:57	18:10	08:14	18:30
30	06:01	20:09			07:07	18:43	09:24	19:18
31	07:16	20:45			08:17	19:17		

	MAY		JUNE		JULY		AUGUST	
1	10:29	20:12	11:29	21:58	10:56	22:37	10:37	DNS
2	11:26	21:10	12:01	22:56	11:21	23:30	11:05	00:07
3	12:16	22:11	12:29	23:52	11:45	DNS	11:38	01:05
4	12:57	23:11	12:55	DNS	12:09	00:25	12:17	02:07
5	13:32	DNS	13:19	00:46	12:36	01:20	13:04	03:11
6	14:02	00:10	13:44	01:40	13:07	02:18	14:01	04:14
7	14:28	01:06	14:09	02:35	13:43	03:19	15:07	05:15
8	14:53	02:01	14:38	03:32	14:26	04:23	16:19	06:08
9	15:18	02:55	15:11	04:32	15:19	05:29	17:34	06:55
10	15:42	03:50	15:50	05:36	16:21	06:32	18:47	07:35
11	16:09	04:46	16:38	06:41	17:31	07:30	19:59	08:10
12	16:39	05:45	17:34	07:46	18:44	08:20	21:08	08:42
13	17:14	06:46	18:39	08:47	19:56	09:03	22:17	09:13
14	17:56	07:50	19:49	09:41	21:07	09:39	23:25	09:45
15	18:46	08:55	21:00	10:27	22:15	10:12	DNR	10:19
16	19:45	09:58	22:10	11:06	23:22	10:43	00:34	10:58
17	20:50	10:55	23:17	11:40	DNR	11:13	01:41	11:41
18	21:59	11:45	DNR	12:11	00:28	11:44	02:46	12:32
19	23:09	12:28	00:23	12:40	01:34	12:19	03:46	13:27
20	DNR	13:05	01:29	13:10	02:42	12:58	04:38	14:27
21	00:17	13:37	02:35	13:43	03:48	13:44	05:23	15:28
22	01:24	14:08	03:42	14:19	04:52	14:36	06:01	16:28
23	02:31	14:38	04:50	15:00	05:50	15:33	06:33	17:26
24	03:37	15:09	05:57	15:49	06:40	16:34	07:01	18:22
25	04:45	15:43	07:00	16:43	07:23	17:35	07:27	19:16
26	05:54	16:22	07:56	17:43	08:00	18:35	07:51	20:10
27	07:04	17:07	08:45	18:45	08:31	19:33	08:15	21:04
28	08:11	17:58	09:26	19:46	08:58	20:28	08:39	21:59
29	09:12	18:56	10:00	20:45	09:23	21:23	09:06	22:56
30	10:06	19:56	10:30	21:42	09:47	22:16	09:36	23:56
31	10:51	20:58			10:11	23:10	10:12	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:55	00:57	11:37	01:45	13:58	02:29	15:08	02:01
2	11:46	01:59	12:45	02:35	15:07	03:01	16:17	02:34
3	12:46	03:00	13:56	03:19	16:16	03:32	17:29	03:10
4	13:54	03:55	15:08	03:57	17:27	04:04	18:42	03:51
5	15:07	04:44	16:19	04:32	18:40	04:38	19:51	04:40
6	16:21	05:26	17:30	05:04	19:54	05:18	20:53	05:37
7	17:34	06:04	18:42	05:36	21:06	06:03	21:46	06:39
8	18:46	06:37	19:54	06:10	22:12	06:56	22:30	07:44
9	19:57	07:10	21:08	06:47	23:09	07:55	23:06	08:48
10	21:07	07:42	22:20	07:29	23:57	08:58	23:37	09:50
11	22:19	08:16	23:27	08:17	DNR	10:02	DNR	10:48
12	23:29	08:54	DNR	09:11	00:36	11:03	00:04	11:43
13	DNR	09:37	00:28	10:11	01:09	12:02	00:29	12:37
14	00:37	10:26	01:19	11:12	01:37	12:58	00:53	13:31
15	01:40	11:21	02:02	12:14	02:03	13:53	01:17	14:26
16	02:35	12:20	02:38	13:13	02:27	14:46	01:44	15:22
17	03:23	13:21	03:08	14:10	02:51	15:40	02:13	16:21
18	04:02	14:21	03:35	15:06	03:16	16:36	02:47	17:23
19	04:36	15:20	04:00	16:00	03:44	17:34	03:28	18:25
20	05:05	16:16	04:24	16:53	04:14	18:34	04:16	19:26
21	05:31	17:11	04:48	17:48	04:51	19:36	05:13	20:22
22	05:56	18:05	05:14	18:44	05:34	20:37	06:17	21:11
23	06:19	18:59	05:42	19:42	06:25	21:35	07:25	21:54
24	06:44	19:54	06:14	20:43	07:23	22:28	08:33	22:31
25	07:10	20:50	06:52	21:44	08:27	23:14	09:41	23:03
26	07:39	21:49	07:36	22:44	09:34	23:54	10:47	23:34
27	08:12	22:49	08:29	23:40	10:41	DNS	11:53	DNS
28	08:52	23:50	09:28	DNS	11:48	00:29	12:58	00:03
29	09:39	DNS	10:34	00:31	12:54	01:01	14:05	00:34
30	10:34	00:50	11:41	01:15	14:00	01:31	15:14	01:07
31			12:50	01:54			16:24	01:46

Note: DNR or DNS means Moon does not rise/set on that day. The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	05:23	20:32	07:58	20:54	06:43	19:20	09:04	19:26
2	06:38	21:16	09:08	21:23	07:55	19:50	10:14	20:08
3	07:54	21:54	10:17	21:53	09:06	20:21	11:22	20:57
4	09:07	22:26	11:25	22:23	10:16	20:55	12:24	21:51
5	10:16	22:55	12:32	22:57	11:25	21:33	13:17	22:49
6	11:23	23:23	13:38	23:36	12:33	22:16	14:02	23:50
7	12:29	23:52	14:42	DNS	13:36	23:06	14:40	DNS
8	13:34	DNS	15:43	00:21	14:33	DNS	15:11	00:50
9	14:40	00:23	16:36	01:11	15:22	00:00	15:39	01:48
10	15:45	00:57	17:23	02:07	16:04	00:59	16:04	02:45
11	16:48	01:37	18:03	03:06	16:39	01:59	16:27	03:41
12	17:47	02:24	18:36	04:06	17:09	02:58	16:50	04:37
13	18:39	03:16	19:05	05:05	17:35	03:56	17:14	05:33
14	19:24	04:13	19:31	06:02	18:00	04:53	17:40	06:31
15	20:02	05:13	19:55	06:59	18:23	05:48	18:10	07:31
16	20:34	06:13	20:18	07:54	18:46	06:44	18:45	08:34
17	21:02	07:12	20:41	08:49	19:10	07:40	19:27	09:38
18	21:27	08:09	21:06	09:46	19:37	08:38	20:17	10:43
19	21:51	09:05	21:34	10:44	20:08	09:38	21:17	11:44
20	22:14	10:00	22:06	11:45	20:44	10:41	22:23	12:39
21	22:38	10:56	22:46	12:49	21:28	11:46	23:34	13:26
22	23:04	11:53	23:34	13:55	22:22	12:49	DNR	14:07
23	23:34	12:53	DNR	15:00	23:24	13:49	00:45	14:42
24	DNR	13:57	00:33	16:00	DNR	14:43	01:56	15:13
25	00:10	15:04	01:42	16:52	00:34	15:29	03:07	15:43
26	00:54	16:12	02:57	17:37	01:48	16:09	04:17	16:12
27	01:49	17:18	04:13	18:15	03:02	16:44	05:27	16:44
28	02:55	18:16	05:29	18:49	04:16	17:15	06:39	17:18
29	04:10	19:06			05:28	17:45	07:51	17:58
30	05:27	19:47			06:40	18:16	09:01	18:45
31	06:44	20:22			07:52	18:49		

	MAY		JUNE		JULY		AUGUST	
1	10:07	19:38	11:09	21:26	10:34	22:08	10:10	23:42
2	11:06	20:36	11:41	22:25	10:57	23:03	10:37	DNS
3	11:56	21:37	12:08	23:23	11:20	23:59	11:08	00:42
4	12:37	22:39	12:32	DNS	11:44	DNS	11:45	01:45
5	13:11	23:39	12:56	00:18	12:09	00:55	12:31	02:49
6	13:41	DNS	13:19	01:13	12:38	01:54	13:27	03:53
7	14:07	00:36	13:43	02:09	13:12	02:56	14:32	04:54
8	14:30	01:33	14:10	03:08	13:54	04:01	15:45	05:48
9	14:53	02:28	14:41	04:09	14:45	05:07	17:01	06:34
10	15:17	03:24	15:19	05:13	15:46	06:11	18:16	07:13
11	15:42	04:21	16:05	06:19	16:56	07:09	19:29	07:47
12	16:11	05:20	17:00	07:25	18:10	07:59	20:40	08:18
13	16:44	06:23	18:04	08:26	19:24	08:41	21:50	08:48
14	17:24	07:28	19:14	09:20	20:36	09:17	23:00	09:18
15	18:13	08:34	20:27	10:06	21:46	09:49	DNR	09:50
16	19:10	09:37	21:38	10:44	22:54	10:18	00:10	10:27
17	20:16	10:35	22:47	11:17	DNR	10:47	01:19	11:09
18	21:25	11:25	23:55	11:47	00:02	11:17	02:25	11:58
19	22:36	12:07	DNR	12:15	01:10	11:50	03:25	12:53
20	23:46	12:43	01:02	12:44	02:18	12:27	04:18	13:53
21	DNR	13:15	02:09	13:15	03:26	13:11	05:03	14:54
22	00:55	13:44	03:17	13:49	04:31	14:02	05:41	15:56
23	02:03	14:12	04:26	14:29	05:29	14:59	06:12	16:55
24	03:10	14:42	05:35	15:16	06:20	16:00	06:40	17:53
25	04:20	15:14	06:39	16:09	07:03	17:03	07:04	18:48
26	05:30	15:51	07:36	17:09	07:39	18:04	07:27	19:43
27	06:41	16:34	08:25	18:11	08:10	19:03	07:50	20:38
28	07:49	17:25	09:06	19:14	08:36	20:00	08:13	21:34
29	08:52	18:21	09:39	20:14	09:00	20:55	08:39	22:32
30	09:46	19:23	10:08	21:12	09:23	21:50	09:08	23:33
31	10:31	20:25			09:46	22:45	09:41	DNS

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	10:22	00:35	11:03	01:25	13:28	02:06	14:41	01:36
2	11:12	01:38	12:11	02:15	14:38	02:37	15:52	02:06
3	12:12	02:39	13:23	02:58	15:49	03:07	17:05	02:40
4	13:20	03:35	14:36	03:35	17:01	03:37	18:19	03:20
5	14:33	04:23	15:49	04:09	18:15	04:10	19:29	04:07
6	15:48	05:05	17:02	04:40	19:30	04:47	20:32	05:03
7	17:03	05:41	18:15	05:10	20:44	05:31	21:26	06:05
8	18:16	06:14	19:29	05:42	21:51	06:23	22:10	07:10
9	19:29	06:45	20:44	06:17	22:49	07:21	22:46	08:16
10	20:41	07:15	21:57	06:57	23:37	08:24	23:16	09:18
11	21:54	07:48	23:06	07:44	DNR	09:28	23:42	10:18
12	23:06	08:24	DNR	08:37	00:16	10:31	DNR	11:15
13	DNR	09:05	00:07	09:37	00:48	11:31	00:06	12:10
14	00:15	09:53	00:59	10:39	01:16	12:29	00:29	13:05
15	01:19	10:47	01:42	11:41	01:40	13:25	00:52	14:01
16	02:15	11:46	02:17	12:42	02:04	14:20	01:17	14:58
17	03:03	12:48	02:47	13:40	02:26	15:15	01:45	15:58
18	03:42	13:49	03:13	14:37	02:50	16:11	02:17	17:01
19	04:15	14:49	03:37	15:32	03:16	17:10	02:56	18:04
20	04:44	15:47	04:00	16:27	03:46	18:11	03:43	19:05
21	05:09	16:43	04:23	17:23	04:20	19:14	04:39	20:02
22	05:32	17:38	04:47	18:20	05:02	20:16	05:43	20:51
23	05:55	18:33	05:14	19:19	05:51	21:15	06:51	21:33
24	06:18	19:29	05:44	20:20	06:49	22:08	08:01	22:09
25	06:43	20:26	06:20	21:22	07:53	22:54	09:10	22:41
26	07:10	21:26	07:04	22:23	09:01	23:33	10:18	23:10
27	07:42	22:27	07:55	23:20	10:09	DNS	11:25	23:38
28	08:20	23:29	08:54	DNS	11:17	00:07	12:32	DNS
29	09:06	DNS	10:00	00:11	12:25	00:38	13:40	00:07
30	10:00	00:29	11:08	00:55	13:32	01:07	14:50	00:39
31			12:18	01:33			16:01	01:15

LUNAR OCCULTATIONS 2006

INTRODUCTION

An occultation is when a body passes in front of a more distant astronomical object. As viewed from Earth, no Solar System body occults more stars, more often, than our own Moon. The reasons for this are:

1. Its large angular size. Although the Moon is small in comparison to the planets, it appears large (0.5° wide) because of its proximity. The Moon travels along a 0.5° wide path across the sky, as does the Sun.
2. The rapid motion of the Moon across the sky. It completes one orbit about every 28 days.
3. With it moving approximately in the plane of the ecliptic, as do most Solar System bodies, each month the Moon crosses the heavily star populated Milky Way. It also occasionally occults the Sun and the planets. An eclipse of the Sun is indeed the most spectacular lunar occultation!

From month to month the Moon does not occult the same stars. In fact over a number of years it drifts in declination between plus and minus 28°. The brighter stars the Moon occults are listed in the Zodiacal Catalogue (ZC). There are about 3500 stars in the ZC.

The Moon moves from west to east, so it rises and sets later from day to day. From just after New Moon to just before Full Moon, stars being occulted will disappear behind part of the dark limb and reappear from the bright limb. The limb is another way of saying the edge of the Moon. After Full Moon a star will disappear on the bright limb and reappear on the dark limb. There is no dark limb at the time of Full Moon.

Dark limb events, in particular disappearances, are the easiest to observe. Following a star until it 'winks out' is much easier than scanning the lunar limb, waiting for it to suddenly reappear. The brighter the star, the more spectacular the event. The following tables present the easier to observe occultations for 2006 as predicted for **Adelaide**, **Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth** and **Sydney**. Both events, the disappearance and reappearance, are not necessarily included. An event may not be present because:

1. The Moon is in daylight
2. The Moon is too close to or below the horizon.
3. For faint stars, events on a bright limb (in particular reappearances) are difficult to observe and have been omitted.

THE TIMING OF OCCULTATIONS.

Besides being a spectacular event, occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

TIMING EQUIPMENT. For a single event, such as a normal occultation, a stop-watch and the telephone time signal as a reference are required. For multiple events, the amateur may tape record simultaneously a shortwave radio time signal with his own voice calling out the events (e.g., star gone … now!) The tape would be later played back (often at a slower speed) and the precise times determined. An accuracy of within 0.2 seconds is not unusual for the experienced observer.

TELESCOPE REQUIREMENTS. These vary greatly with the brightness of the star being observed, the brightness of the Moon (how close to Full Moon) and whether the event is on a bright or dark limb. Disappearances of first magnitude stars on the dark limb can be observed with the naked-eye!

For further information on timing methods for occultations it would be worth contacting your local astronomical society (see Part III).

LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 7th magnitude. The criteria for selection are complex involving the Sun and Moon altitude, star magnitude and whether it is a bright or dark limb event.

EXPLANATION

EST the date and time of the occultation, hr and min are in EST except Adelaide and Darwin using CST and Perth using WST.

OBJECT
- n, nn, nnn, nnnn — ZC catalogue number
- nnnnn or nnnnnn — SAO catalogue number
- X nnnnn — USNO XZ catalogue number
- name of planet, satellite or deep sky object.

PD event, consisting of two letters.
The first letter is the type of Event: 'D' = Disappearance and 'R' = Reappearance. The second letter represents: 'D' = Dark limb, 'B' = a bright limb event. A 'G' indicates a graze at or near the location.

Mag magnitude of the star.

Elg elongation or separation of the Moon from the Sun as measured in degrees.

Alt. altitude of the Moon during the occultation.

PA position angle is the position the event occurs on the limb of the Moon (measured as degrees east of north).

A coefficient of longitude (see below)

B coefficient of latitude (see below)

NB. For some stars, close to 'grazing', A and B values become useless, and no values are recorded.

CALCULATING EVENT TIME FOR OTHER LOCATIONS

Unless the event is close to a 'graze' (PA is close to 0° or 180°) this method will give a good approximation for any location within about 500km from the city's table you are working from. The formula is:

Predicted Time at your location

$$= \text{Time from Table} + (A \times n) + (B \times p)$$

where 'n' and 'p' are the **change** in longitude and latitude respectively (in decimal degrees).

'n' is positive (+) if east, negative (-) if west

'p' is positive (+) if north, negative (-) if south.

The values for A and B are taken from the tables.

It is best to use data for the city which you are closest to.

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the disappearance of ZC1122 on March 9th for their location in Albury NSW (146° 55' E, 36° 05' S), see page 139. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)

= 149°.13 – 146°.92 = – 2°.21 — 'n' (-)

The change in latitude from Canberra (decimal degrees)

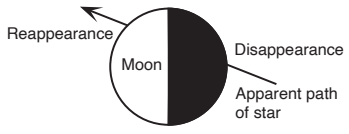
= 35°.25 – 36°.08 = – 0°.83 — 'p' (–)

From the Canberra table, the time of the event is 22:19 EST and the values of A and B are +1.7 and +0.4 respectively.

Therefore the equation becomes:

$$22{:}19 + (1.7 \times -2°.21) + (0.4 \times -0°.83)$$

$$= 22{:}19 + (-3.76) + (-$$



Lunar occultation predictions were calculated using Win Occult version 3.1 by D. Herald, PO Box 254 Woden ACT 2606. heraldd@canberra.DIALix.oz.au

LUNAR OCCULTATION TABLE

ADELAIDE (34° 54' S, 138° 36' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 07 22:59	230	DD	7.3	99	13	57	+0.9	+1.8
Jan 08 21:17	92911	DD	7.5	111	31	120	+3.1	-0.5
Jan 09 22:47	75845	DD	7.6	124	22	63	+1.8	+1.5
Jan 10 22:12	616	DD	5.4	135	27	5	+1.4	+3.9
Jan 11 00:00	76514	DD	7.2	136	17	115	+1.4	+0.4
Jan 11 22:37	768	DD	7.0	147	26	146	+2.7	-2.2
Jan 12 22:41	77956	DD	7.5	158	26	123	+2.6	-1.0
Jan 14 01:49	1081	DD	6.5	170	21	115	+1.6	+0.1
Jan 22 02:39	1911	RD	7.3	100	43	347	+0.2	-2.9
Jan 25 03:53	2257	RD	6.7	64	38	254	+1.4	-0.6
Jan 26 03:05	2409	RD	7.0	52	19	240	+0.7	-0.3
Jan 27 02:41	2554	RD	4.5	39	5	266	-0.3	-0.8
Feb 05 19:53	440	DD	4.7	92	29	109	+2.5	+0.2
Feb 05 20:55	440	RB	4.7	92	22	204	+1.6	+2.5
Feb 07 20:36	76784	DD	7.5	116	26	46	+2.2	+1.4
Feb 09 20:39	1032	DD	5.4	139	25	100	+2.4	-0.7
Feb 11 22:05	1279	DD	6.4	161	28	144	+1.9	-1.9
Feb 12 00:10	1283	DD	7.0	162	30	76	+3.2	+0.9
Feb 12 02:13	1290	DD	6.9	162	20	74	+2.4	+1.9
Feb 13 00:22	1393	DD	6.5	172	35	139	+1.6	-1.3
Feb 13 21:25	1479	RD	6.4	175	20	266	+1.5	-1.2
Feb 14 21:06	1576	RD	5.3	165	14	250	+1.0	-0.8
Feb 19 00:31	1971	RD	5.5	120	36	327	+0.3	-2.4
Feb 19 03:26	158190	RD	7.5	120	66	13	-1.2	-5.2
Feb 22 00:52	2349	DB	2.9	85	18	99	0.0	-1.2
Feb 22 01:49	2349	RD	2.9	85	30	305	+0.1	-1.8
Feb 22 05:15	Antares	DB	1.1	83	70	110	+1.8	-1.4
Feb 22 06:42	Antares	RD	1.1	83	81	289	+2.2	-0.9
Mar 08 19:58	78397	DD	7.6	108	26	124	+2.3	-0.7
Mar 09 21:29	1122	DD	3.8	120	26	122	+1.9	-0.4
Mar 09 22:55	1122	RB	3.8	120	19	281	+1.6	+0.6
Mar 09 23:28	1132	DD	6.4	120	16	119	+1.0	+0.2
Mar 12 23:58	1462	DD	7.3	154	37	129	+1.6	-0.8
Mar 16 21:17	138955	RD	7.2	163	26	317	+0.5	-2.2
Mar 18 01:21	158011	RD	7.1	150	64	295	+2.0	-1.4
Mar 21 00:28	2295	RD	7.2	116	38	253	+1.4	-0.6
Mar 21 00:37	2299	RD	6.2	116	40	342	-0.4	-3.1
Mar 23 02:48	2617	DB	4.6	90	44	88	+1.1	-1.0
Mar 23 03:16	186286	RD	7.1	90	50	301	+0.9	-2.1
Mar 23 04:02	2617	RD	4.6	90	59	289	+1.5	-1.6
Mar 23 04:16	186346	RD	7.6	90	62	222	+2.8	+2.3
Mar 24 01:32	2784	DB	3.3	78	18	149	-1.0	-3.1
Mar 24 01:56	187672	RD	7.4	78	22	307	-0.3	-2.1
Mar 24 02:05	2784	RD	3.3	78	24	216	+1.4	+1.1
Mar 27 05:02	3256	RD	6.1	36	18	239	+0.5	-0.1
Mar 27 05:24	164931	RD	7.6	36	22	292	+0.5	-2.3
Apr 05 21:21	1081	DD	6.5	89	15	168	-0.7	-2.1
Apr 10 22:26	118702	DD	7.5	145	47	76	+4.2	+1.1
Apr 12 01:34	119114	DD	7.2	157	38	179	0.0	-3.1
Apr 12 03:04	119138	DD	7.4	157	22	115	+0.8	+0.2
Apr 12 03:58	1730	DD	6.2	158	11	156	+0.2	-1.3
Apr 13 01:10	1814	DD	6.7	168	52	86	+2.8	+1.1
Apr 14 22:51	2017	RD	6.4	170	57	284	+1.8	-1.4
Apr 14 23:03	158333	RD	7.2	170	59	332	+0.7	-2.6
Apr 15 22:56	158880	RD	7.5	158	52	261	+2.1	-0.7
Apr 15 23:52	2129	RD	7.4	158	63	300	+1.5	-1.8
Apr 16 23:38	2257	RD	6.7	146	52	347	-0.3	-3.5
Apr 17 03:42	2269	RD	5.4	145	71	319	+2.0	-2.1
Apr 17 23:26	2404	RD	6.7	134	40	281	+0.8	-1.4
Apr 18 22:58	2545	RD	6.4	122	24	348	-1.5	-3.9
Apr 20 03:24	2743	RD	7.6	107	65	317	+1.5	-3.6
Apr 23 02:15	164651	RD	7.6	69	12	250	+0.2	-0.5
May 02 20:07	1032	DD	5.4	58	7	59	+1.9	+2.4
May 04 18:29	1274	DD	5.7	80	31	142	+1.5	-1.2
May 04 19:20	1279	DD	6.4	81	28	102	+2.1	+0.2
May 05 21:17	1393	DD	6.5	92	25	77	+2.6	+1.9
May 06 19:19	1485	DD	7.1	103	40	180	+0.1	-2.9
May 11 19:00	1971	DD	5.5	158	35	70	+1.9	-0.6
May 11 23:14	1986	DD	7.1	160	68	122	+2.0	-1.2
May 13 01:40	2099	DD	6.9	172	59	142	+1.6	-1.7
May 14 05:27	2237	RD	5.0	173	26	257	+0.3	+1.6
May 14 19:09	2349	DB	2.9	165	14	113	-0.2	-1.4
May 14 20:05	2349	RD	2.9	165	25	289	+0.1	-1.5
May 14 23:24	Antares	DB	1.1	163	65	129	+1.2	-2.2
May 15 00:44	Antares	RD	1.1	163	79	273	+2.3	-0.4
May 15 02:01	2373	RD	6.1	163	77	278	+2.3	-0.1
May 16 05:30	185573	RD	6.8	149	49	309	+2.1	-0.9
May 19 06:01	189613	RD	7.2	110	74	203	+0.8	+3.0
Jun 03 19:03	99198	DD	7.3	83	42	131	+1.6	-1.0
Jun 05 23:50	138591	DD	7.6	107	20	106	+0.8	+0.6
Jun 06 22:46	1836	DD	6.3	118	43	181	+0.2	-3.9
Jun 10 20:01	2295	DD	7.2	164	50	137	+0.5	-2.3
Jun 11 03:22	2332	DD	6.1	166	36	44	+0.2	+3.4
Jun 11 06:03	2349	DD	2.9	167	6	55	-0.7	+1.8
Jun 12 19:57	2601	RD	6.8	169	27	333	-0.7	-3.1
Jun 12 21:50	2617	DB	4.6	169	49	154	-0.1	-4.1
Jun 12 21:58	186286	RD	7.1	169	51	239	+1.9	+0.4
Jun 12 22:31	2617	RD	4.6	168	58	222	+2.7	+2.1
Jun 13 01:20	186461	RD	7.4	167	82	283	+2.3	-0.6
Jun 13 03:56	2644	RD	6.4	167	54	239	+1.0	+2.0
Jun 13 20:48	187716	RD	7.2	157	25	335	-1.1	-4.2
Jun 13 21:48	2796	RD	6.9	156	37	264	+0.9	-0.9
Jun 13 23:45	2805	RD	7.1	155	60	311	+1.4	-3.2
Jun 17 00:55	164931	RD	7.6	115	33	178	+0.8	+4.8
Jun 17 03:08	3268	DB	5.3	114	58	11	+0.8	+3.0
Jun 17 04:05	3268	RD	5.3	114	65	278	+2.8	-0.9
Jun 18 05:08	3405	RD	7.0	100	60	296	+4.6	-2.9
Jun 20 02:24	98	RD	6.0	74	11	286	+0.8	-2.2
Jul 01 19:23	118636	DD	7.3	65	33	146	+0.7	-1.1
Jul 01 20:25	1609	DD	4.6	65	23	143	+0.5	-0.8
Jul 01 21:13	118658	DD	7.3	65	14	141	+0.3	-0.6
Jul 01 21:30	1609	RB	4.6	65	11	288	+0.5	+0.6
Jul 03 21:19	1795	DD	6.9	87	35	103	+1.4	+0.6
Jul 06 21:56	2115	DD	7.2	121	62	77	+2.5	+1.7
Jul 07 20:07	2237	DD	5.0	133	75	103	+2.2	-1.0
Jul 07 21:33	2237	RB	5.0	133	76	306	+2.0	-1.5
Jul 07 22:03	183713	DD	7.4	133	72	178	+0.9	-7.3
Jul 07 23:14	2248	DD	7.6	134	59	150	+1.9	-2.5
Jul 08 03:47	2269	DD	5.4	136	6	103	-0.1	+0.7
Jul 09 19:12	185573	DD	6.8	157	45	83	+1.2	-0.8
Jul 10 04:45	2583	DD	5.8	161	19	101	+0.3	+0.8
Jul 12 19:41	3031	RD	5.9	161	12	295	-0.3	-1.9
Jul 12 21:49	3046	RD	7.1	160	37	281	+0.9	-1.6
Jul 12 22:35	3050	RD	7.4	160	46	276	+1.3	-1.3
Jul 13 04:37	3078	DB	4.9	158	52	51	+0.8	+1.9
Jul 13 05:42	3078	RD	4.9	157	39	245	+0.6	+1.6
Jul 13 20:56	3190	RD	2.9	147	13	261	+0.2	-0.8
Jul 14 01:16	3210	RD	7.2	145	62	257	+2.0	0.0
Jul 14 02:39	3217	RD	7.4	145	70	198	+0.8	+2.7
Jul 14 05:22	3224	RD	7.6	143	50	220	+0.7	+2.1
Jul 14 22:29	146296	RD	7.4	132	17	214	+0.5	+0.8
Jul 16 05:28	146911	RD	7.1	116	53	236	+1.6	+1.4
Jul 20 04:53	75832	RD	7.3	64	20	261	+1.4	-0.7
Jul 29 20:11	118917	DD	7.3	46	12	122	+0.4	+0.1
Aug 03 19:59	2183	RB	5.5	102	69	303	+2.1	-1.1
Aug 05 20:07	2470	DD	6.1	126	81	27	+3.9	+8.1
Aug 06 01:49	2505	DD	5.3	129	26	131	+1.1	-0.3
Aug 06 19:58	186536	DD	7.5	139	69	144	+1.3	-3.9
Aug 06 20:59	2644	DD	6.4	140	80	66	+2.3	+1.0
Aug 06 23:42	2660	DD	6.2	140	63	126	+2.6	-1.2
Aug 08 23:46	189348	DD	7.6	167	78	45	+1.5	+1.9
Aug 09 02:18	189425	DD	7.5	169	53	20	+0.1	+2.9
Aug 11 00:15	3295	RD	7.0	163	61	311	+6.3	-8.2
Aug 11 02:01	3307	DB	4.8	163	65	30	+1.0	+2.1
Aug 11 03:09	3307	RD	4.8	162	57	251	+1.7	+1.3
Aug 11 22:38	3430	RD	5.6	150	32	193	+0.5	+2.1
Aug 12 00:05	3437	RD	6.8	149	47	213	+1.0	+1.3
Aug 13 03:03	109127	RD	7.2	134	51	300	+5.7	-3.3
Aug 14 01:09	109700	RD	7.3	121	30	187	-0.1	+2.1
Aug 14 01:18	166	RD	6.7	121	32	238	+1.1	+0.2
Aug 14 03:02	173	RD	6.5	120	43	194	+0.5	+1.9
Aug 15 05:57	317	RD	6.4	106	36	179	+0.2	+3.0
Aug 16 02:28	438	RD	6.8	94	18	211	+0.2	+0.8
Aug 31 20:45	X134481	DD	7.0	84	47	170	+2.7	-6.1
Aug 31 20:45	2268	DD	4.5	84	47	170	+2.7	-6.1
Aug 31 20:58	2273	DD	5.9	84	45	127	+1.6	-0.5
Aug 31 21:12	2268	RB	4.5	84	42	208	-0.2	+7.2
Sep 03 00:17	2583	DD	5.8	109	29	1	-3.6	+8.0
Sep 03 20:36	2743	DD	7.6	121	82	66	+2.1	+1.2
Sep 05 02:57	2934	DD	7.6	137	19	46	-0.3	+1.8
Sep 06 01:08	3078	DD	4.9	149	50	52	+0.8	+1.8
Sep 06 02:12	3078	RB	4.9	150	37	244	+0.6	+1.6
Sep 06 20:06	3210	DD	7.2	162	45	52	+1.3	+0.5
Sep 06 21:39	3217	DD	7.4	162	61	100	+2.4	-1.3
Sep 07 00:08	3224	DD	7.6	163	66	71	+1.8	+1.1
Sep 07 23:37	Uranus	DD	5.7	177	62	65	+1.8	+0.8
Sep 08 00:48	Uranus	RB	5.7	178	61	213	-1.0	+1.9
Sep 08 04:09	3383	RB	6.2	179	29	197	+0.1	+2.3
Sep 08 22:25	146911	RD	7.1	168	41	265	+1.7	-0.7
Sep 09 02:47	128449	RD	7.6	167	47	267	+2.1	+0.9
Sep 10 01:37	105	DB	4.4	153	47	89	+2.6	-0.1
Sep 10 02:34	105	RD	4.4	152	46	189	+0.5	+2.4
Sep 13 00:47	518	RD	6.0	112	12	234	+0.5	0.0
Sep 13 04:44	529	RD	6.1	111	30	258	+2.2	+0.4
Sep 14 02:34	696	RD	7.5	99	16	257	+1.3	-0.6
Sep 15 03:31	850	RD	6.0	86	15	227	+0.7	+0.2
Sep 15 04:54	855	RD	6.4	86	22	269	+2.1	-0.6
Sep 15 04:54	77394	RD	7.1	86	22	271	+2.2	-0.6
Sep 16 03:45	1018	RD	5.8	74	9	258	+1.0	-0.8
Sep 27 21:48	183713	DD	7.4	55	11	121	+0.3	+0.2
Sep 29 23:48	185573	DD	6.8	79	11	70	-0.4	+1.4
Oct 02 19:40	189348	DD	7.6	115	77	20	+1.1	+3.4
Oct 04 21:29	3295	DD	7.0	143	66	23	+0.9	+2.3
Oct 04 23:50	3307	DD	4.8	144	54	64	+1.4	+1.5
Oct 05 00:57	3307	RB	4.8	144	42	220	+0.6	+2.0
Oct 05 21:04	3437	DD	6.8	157	52	112	+3.3	-2.6
Oct 07 21:12	166	RD	6.7	174	27	234	+0.8	+0.2
Oct 07 22:46	173	RD	6.5	173	39	195	+0.4	+1.7
Oct 08 23:54	317	RD	6.4	158	34	221	+1.0	+0.8
Oct 11 00:15	616	RD	5.4	131	16	181	-1.2	+2.8
Oct 12 02:50	788	RD	6.8	117	23	201	+0.7	+1.8
Oct 13 01:14	948	RD	4.3	105	6	325	+2.6	-3.7
Oct 14 02:30	1103	RD	5.8	93	10	257	+1.0	-0.8
Oct 26 18:34	2470	DD	6.1	47	46	43	+0.4	+3.2
Oct 27 21:41	186598	DD	7.5	60	21	51	-0.3	+1.9
Oct 28 20:12	2805	DD	7.1	71	49	87	+1.3	+1.1
Oct 31 23:33	3245	DD	6.9	111	34	139	+7.5	-6.1
Oct 31 23:41	3245	RD	6.9	111	33	152	-6.2	+9.6
Nov 02 00:00	3383	DD	6.2	125	35	121	+2.6	-0.3
Nov 02 23:19	128449	DD	7.6	139	45	50	+1.3	+1.7
Nov 06 20:49	518	RD	6.0	165	8	264	+0.8	-0.9
Nov 06 22:51	76046	RD	7.1	165	24	201	+0.3	+1.2
Nov 07 00:13	529	RD	6.1	164	29	292	+2.9	-1.1
Nov 07 00:17	76081	RD	7.5	164	30	214	+1.2	+1.1
Nov 08 03:15	76772	RD	7.2	150	24	249	+2.1	+0.9
Nov 08 04:03	76784	RD	7.5	150	20	233	+2.1	+1.6
Nov 11 01:34	1181	RD	7.0	113	14	263	+1.3	-0.9
Nov 28 22:14	3333	DD	6.4	93	32	4	-0.2	+2.9
Dec 02 00:55	197	DD	7.0	134	16	30	+0.9	+2.2
Dec 03 00:58	336	DD	7.4	148	20	92	+1.4	+1.0
Dec 04 20:38	616	DD	5.4	171	16	107	+1.9	-1.6
Dec 05 23:26	788	RD	6.8	170	24	259	+2.0	-0.2
Dec 05 23:47	77089	RD	7.3	170	25	222	+1.6	+0.9
Dec 06 02:53	801	RD	6.5	169	19	247	+2.0	+1.3
Dec 08 03:04	79402	RD	7.3	145	28	306	+1.9	-0.7
Dec 09 00:15	1251	RD	5.9	134	16	202	-0.3	+6.6
Dec 09 03:40	80165	RD	7.5	133	31	295	+2.1	-0.6
Dec 16 03:43	158085	RD	7.3	55	24	353	-0.4	-2.9
Dec 19 14:01	Antares	DB	1.1	18	49	45	+0.8	+3.5
Dec 19 14:53	Antares	RD	1.1	18	39	320	+1.8	-1.2

LUNAR OCCULTATION TABLE

BRISBANE (27° 30' S, 153° 01' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 20:23	164844	DD	7.4	45	15	54	0.0	+1.5
Jan 10 21:08	76472	DD	7.2	135	36	113	+3.3	-0.7
Jan 11 23:32	768	DD	7.0	147	27	120	+1.9	-0.3
Jan 20 23:51	1790	RD	6.9	112	22	311	+0.5	-2.0
Jan 26 03:37	2409	RD	7.0	52	29	284	+0.4	-1.2
Jan 27 02:58	2554	RD	4.5	39	10	303	-0.5	-1.4
Feb 05 20:56	440	DD	4.7	92	23	99	+1.6	+0.7
Feb 05 20:56	X 54005	DD	5.6	92	23	99	+1.6	+0.7
Feb 05 21:03	438	DD	6.8	92	21	32	+1.7	+2.6
Feb 06 19:54	574	DD	6.8	104	34	116	+2.9	-0.6
Feb 06 21:32	579	DD	6.4	104	22	359	+3.8	+9.6
Feb 07 22:54	731	DD	6.0	116	16	134	+0.6	-0.7
Feb 08 19:53	77506	DD	7.4	127	33	74	+2.7	+0.3
Feb 09 21:46	1032	DD	5.4	139	33	83	+3.0	+0.4
Feb 11 20:21	80209	DD	7.1	160	27	125	+2.2	-1.9
Feb 11 22:05	1274	DD	5.7	161	37	152	+1.9	-2.4
Feb 11 22:56	1279	DD	6.4	161	39	114	+2.5	-0.8
Feb 13 01:18	1393	DD	6.5	172	37	92	+2.8	+0.6
Feb 14 21:49	1576	RD	5.3	165	30	274	+1.8	-1.2
Feb 22 01:27	2349	DB	2.9	85	29	51	+2.1	+0.9
Feb 22 01:56	2349	RD	2.9	85	35	357	-1.5	-4.2
Feb 22 06:22	Antares	DB	1.1	83	87	63	+3.3	+2.0
Feb 22 07:31	Antares	RD	1.1	83	72	327	+2.4	-3.1
Feb 23 02:35	2505	DB	5.3	72	32	133	0.0	-2.0
Feb 23 03:37	2505	RD	5.3	72	45	262	+1.5	-0.6
Mar 04 19:57	93033	DD	7.2	60	12	82	+0.9	+1.2
Mar 05 20:15	518	DD	6.0	72	15	50	+1.6	+2.0
Mar 07 20:18	824	DD	6.2	96	27	85	+2.3	+0.8
Mar 09 22:00	1119	DD	5.8	120	28	141	+1.1	-1.0
Mar 09 22:32	1122	DD	3.8	120	25	81	+2.4	+1.2
Mar 09 23:37	1122	RB	3.8	120	15	327	0.0	-1.0
Mar 10 22:46	80070	DD	7.5	131	31	179	-0.9	-3.4
Mar 13 01:02	1462	DD	7.3	154	32	71	+3.4	+2.6
Mar 16 21:34	138955	RD	7.2	163	37	351	+0.1	-3.0
Mar 18 01:58	158011	RD	7.1	151	74	346	+0.8	-3.2
Mar 21 01:06	2295	RD	7.2	116	51	300	+1.0	-1.8
Mar 22 23:15	2583	RD	5.8	92	7	318	-0.8	-1.8
Mar 23 03:53	2617	DB	4.6	90	63	30	+4.0	+5.1
Mar 23 04:28	2617	RD	4.6	90	71	343	+0.7	-7.3
Mar 24 01:45	2784	DB	3.3	78	23	98	+0.3	-1.1
Mar 24 02:50	2784	RD	3.3	78	37	267	+1.0	-0.8
Mar 26 03:02	3092	RD	6.3	51	13	251	+0.3	-0.3
Apr 04 19:34	921	DD	6.0	77	23	65	+2.5	+1.7
Apr 05 21:51	1081	DD	6.5	89	12	115	+0.7	+0.2
Apr 12 02:01	119114	DD	7.2	157	31	129	+0.9	-0.6
Apr 14 19:26	2002	RD	6.8	171	22	282	+0.5	-1.3
Apr 14 23:29	2017	RD	6.4	170	72	332	+1.1	-2.7
Apr 15 05:00	2029	RD	4.9	168	26	258	+0.7	+1.6
Apr 15 23:42	158880	RD	7.5	158	69	311	+1.5	-2.1
Apr 16 00:18	2129	RD	7.4	158	76	352	+0.2	-4.1
Apr 17 23:51	2404	RD	6.7	134	50	328	+0.3	-2.8
Apr 18 21:39	185573	RD	6.8	123	12	283	-0.2	-1.1
Apr 20 01:14	2727	RD	7.4	109	44	229	+2.1	+1.1
Apr 22 00:40	189680	RD	7.4	83	11	290	-0.2	-1.5
Apr 23 03:56	3197	RD	6.4	68	38	216	+1.2	+1.4
May 01 10:42	810	RB	1.7	43	10	199	-0.7	+1.8
May 01 18:30	77381	DD	7.0	45	13	129	+0.5	-0.3
May 04 19:22	1274	DD	5.7	80	32	99	+2.2	+0.3
May 06 19:51	1485	DD	7.1	103	46	129	+1.9	-1.1
May 07 18:37	1576	RB	5.3	113	49	329	+1.5	-2.3
May 11 02:59	1886	DD	5.6	149	14	157	+0.5	-1.8
May 12 00:26	1986	DD	7.1	160	58	64	+3.6	+3.6
May 13 02:29	2099	DD	6.9	172	44	109	+1.6	+0.1
May 14 19:33	2349	DB	2.9	165	22	76	+0.7	-0.6
May 14 20:21	2349	RD	2.9	165	33	330	-0.3	-2.5
May 15 00:15	Antares	DB	1.1	163	82	83	+2.9	+0.2
May 15 01:40	Antares	RD	1.1	163	78	312	+2.4	-2.0
May 15 03:00	2373	RD	6.1	163	61	306	+2.3	-1.2
May 15 21:50	2505	RD	5.3	152	40	232	+2.3	+1.0
May 23 04:25	24	RD	6.8	58	31	160	-1.4	+6.9

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 24 03:35	146	RD	4.3	45	7	178	-0.5	+3.2
Jun 03 20:08	99198	DD	7.3	83	37	72	+3.6	+2.7
Jun 05 18:19	1730	DD	6.2	105	61	172	+0.4	-3.2
Jun 06 23:14	1836	DD	6.3	118	34	133	+1.1	-0.9
Jun 10 03:14	2183	DD	5.5	154	18	179	+3.5	-8.7
Jun 10 18:31	2286	DD	5.4	163	36	156	-0.3	-2.7
Jun 10 20:38	2295	DD	7.2	163	63	90	+2.2	-0.7
Jun 11 04:12	2332	DD	6.1	166	19	34	-0.9	+3.5
Jun 12 18:10	2583	RD	5.8	170	10	262	0.0	-0.6
Jun 12 22:16	2617	DB	4.6	169	60	103	+1.7	-1.2
Jun 12 22:53	186286	RD	7.1	168	68	283	+2.1	-1.1
Jun 12 23:41	2617	RD	4.6	168	78	267	+2.5	-0.2
Jun 13 02:20	186461	RD	7.4	167	67	302	+2.8	-1.2
Jun 13 04:49	2644	RD	6.4	167	36	238	+0.3	+1.8
Jun 13 20:49	187672	RD	7.4	157	29	266	+0.7	-0.8
Jun 13 22:20	2796	RD	6.9	156	48	308	+0.9	-2.6
Jun 15 21:40	3090	RD	6.7	130	13	234	+0.5	+0.2
Jun 16 22:55	3240	RD	6.7	116	15	214	+0.6	+1.1
Jun 17 04:11	3268	DB	5.3	114	75	13	+0.7	+3.1
Jun 17 05:16	3268	RD	5.3	114	71	267	+2.8	+0.5
Jun 20 02:36	98	DD	6.0	75	21	337	-2.2	+8.5
Jun 20 02:51	98	RD	6.0	75	24	310	+3.8	-7.8
Jun 22 04:17	375	RD	6.8	48	15	251	+0.7	-0.3
Jun 23 05:34	513	RD	7.3	35	16	219	+0.2	+0.7
Jun 30 18:11	1504	RB	5.4	53	34	358	-0.4	-2.9
Jul 01 20:06	118636	DD	7.3	65	24	99	+1.2	+0.6
Jul 01 21:03	1609	DD	4.6	65	13	101	+0.6	+0.6
Jul 03 22:24	1795	DD	6.9	87	17	49	+1.1	+6.5
Jul 04 17:38	1886	DD	5.6	97	70	138	+1.7	-2.2
Jul 04 19:09	1886	RB	5.6	97	67	309	+2.0	-1.5
Jul 05 18:31	1992	DD	7.5	108	76	190	-1.0	-5.4
Jul 07 21:30	2237	DD	5.0	133	75	44	+4.0	+6.1
Jul 07 22:07	2237	RB	5.0	133	67	356	+1.6	-7.2
Jul 07 22:37	183713	DD	7.4	133	61	130	+2.2	-1.4
Jul 08 16:27	Antares	DD	1.1	143	27	151	-0.5	-2.4
Jul 08 17:17	Antares	RB	1.1	144	38	254	+1.5	-0.4
Jul 12 23:13	3050	RD	7.4	160	61	311	+2.7	-4.7
Jul 13 20:42	3190	DB	2.9	147	14	17	+0.9	+2.2
Jul 13 21:18	3190	RD	2.9	147	22	303	+0.3	-2.9
Jul 14 02:21	3210	RD	7.2	145	78	256	+2.4	+0.7
Jul 14 03:38	3217	RD	7.4	145	68	185	0.0	+3.4
Jul 14 21:44	3332	RD	7.0	133	14	208	+0.5	+1.3
Jul 14 23:13	146296	RD	7.4	132	33	240	+1.0	+0.3
Jul 18 01:22	203	RD	6.8	91	19	263	+0.9	-0.7
Jul 20 03:57	470	RD	6.8	64	21	304	+3.4	-3.7
Jul 21 03:39	616	RD	5.4	52	6	318	+3.5	-5.7
Aug 03 19:45	2183	DD	5.5	102	69	59	+3.3	+3.4
Aug 03 20:41	2183	RB	5.5	102	57	344	+1.9	-4.2
Aug 06 02:29	2505	DD	5.3	129	10	134	+0.7	-0.6
Aug 06 17:59	2617	RB	4.6	138	51	273	+1.5	-0.9
Aug 06 20:42	186536	DD	7.5	139	85	104	+2.6	-0.9
Aug 06 22:09	2645	DD	6.2	140	76	124	+3.0	-1.8
Aug 06 22:16	2644	DD	6.4	140	74	41	+1.7	+3.0
Aug 07 00:40	2660	DD	6.2	140	44	125	+2.2	-0.8
Aug 09 03:07	189425	DD	7.5	168	37	31	0.0	+2.2
Aug 10 19:28	3268	RD	5.3	166	14	274	+0.3	-1.1
Aug 11 01:32	3295	RD	7.0	163	72	290	+4.2	-1.3
Aug 11 03:01	3307	DB	4.8	163	57	43	+1.1	+1.9
Aug 11 04:09	3307	RD	4.8	162	43	238	+1.0	+1.6
Aug 11 20:18	3412	RD	4.2	151	10	175	+0.4	+4.4
Aug 11 23:32	3430	RD	5.6	150	51	203	+0.9	+2.0
Aug 12 01:03	3437	RD	6.8	149	65	209	+1.1	+2.0
Aug 13 04:22	109127	RD	7.2	134	50	273	+2.7	+0.5
Aug 13 22:37	145	RD	6.8	122	12	300	+1.3	-3.5
Aug 14 01:55	109700	RD	7.3	121	46	176	-0.4	+3.1
Aug 14 02:11	166	RD	6.7	121	48	230	+1.5	+1.0
Aug 14 03:54	173	RD	6.5	120	52	175	-0.3	+3.4
Aug 16 03:11	438	RD	6.8	94	33	201	+0.4	+1.6
Aug 17 02:13	579	RD	6.4	82	14	285	+1.6	-1.6
Aug 30 18:49	2134	DD	5.9	71	54	143	+1.9	-2.0

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 31 21:24	X134481	DD	7.0	84	32	144	+1.7	-1.7
Aug 31 21:24	2268	DD	4.5	84	32	144	+1.7	-1.7
Aug 31 21:46	2273	DD	5.9	84	28	115	+1.0	+0.1
Aug 31 22:10	2268	RB	4.5	84	22	226	-0.3	+2.9
Sep 01 17:29	2405	DD	6.6	94	85	91	+2.8	-0.2
Sep 03 00:52	2583	DD	5.8	109	14	12	-1.8	+3.9
Sep 06 02:00	3078	DD	4.9	149	34	62	+0.5	+1.5
Sep 06 17:37	3190	RB	2.9	160	21	288	+0.4	-1.7
Sep 06 21:05	3210	DD	7.2	162	65	38	+1.5	+1.7
Sep 06 22:44	3217	DD	7.4	162	78	102	+3.4	-0.8
Sep 08 00:43	Uranus	DD	5.7	177	65	79	+2.3	+0.9
Sep 08 01:45	Uranus	RB	5.7	178	54	198	+0.5	+2.5
Sep 08 04:56	3383	RB	6.2	179	13	196	-0.1	+2.3
Sep 08 23:22	146911	RD	7.1	169	59	259	+2.4	+0.1
Sep 10 02:52	105	DB	4.4	153	49	112	+3.8	-0.7
Sep 10 03:28	105	RD	4.4	152	44	170	-0.3	+3.9
Sep 13 01:29	518	RD	6.0	112	27	227	+0.9	+0.6
Sep 13 05:52	529	RD	6.1	111	31	261	+2.2	+0.9
Sep 14 03:25	696	RD	7.5	99	31	249	+1.9	+0.1
Sep 15 04:21	850	RD	6.0	86	29	223	+1.6	+1.1
Sep 16 04:31	1018	RD	5.8	74	25	257	+1.9	-0.3
Sep 29 18:44	185400	DD	7.2	76	63	77	+2.0	+1.3
Oct 02 23:22	189425	DD	7.5	116	39	1	-1.1	+3.7
Oct 04 22:30	3295	DD	7.0	143	67	35	+1.1	+2.1
Oct 05 00:50	3307	DD	4.8	144	39	76	+1.2	+1.3
Oct 05 01:47	3307	RB	4.8	144	27	212	+0.1	+2.1
Oct 07 00:22	109127	DD	7.2	172	54	35	+1.2	+1.9
Oct 07 22:00	166	RD	6.7	174	44	230	+1.3	+0.8
Oct 07 23:36	173	RD	6.5	173	52	178	-0.2	+3.0
Oct 09 00:49	317	RD	6.4	158	45	207	+1.2	+1.8
Oct 12 03:58	788	RD	6.8	117	34	206	+2.3	+2.8
Oct 13 01:16	948	DB	4.3	106	15	26	-0.2	+1.7
Oct 13 02:01	948	RD	4.3	105	22	318	+3.1	-2.9
Oct 14 03:17	1103	RD	5.8	93	26	259	+2.0	-0.4
Oct 26 19:27	2470	DD	6.1	47	28	40	-0.4	+2.8
Oct 26 20:05	2474	DD	6.7	47	20	59	-0.2	+1.8
Oct 27 18:55	2617	RB	4.6	58	46	259	+1.2	+1.3
Oct 27 20:04	186461	DD	7.4	59	32	79	+0.6	+1.2
Oct 27 20:04	186434	DD	7.5	59	32	14	-1.3	+4.3
Oct 28 21:05	2805	DD	7.1	71	31	94	+0.8	+0.8
Oct 30 19:19	3078	RB	4.9	96	74	315	+9.6	-8.8
Nov 02 00:56	3383	DD	6.2	125	19	132	+2.0	-2.2
Nov 02 19:44	146911	DD	7.1	137	59	56	+1.7	+1.0
Nov 04 22:44	244	DD	6.7	166	48	14	+0.7	+2.3
Nov 06 21:29	518	RD	6.0	165	24	258	+1.3	-0.4
Nov 06 23:39	76046	RD	7.1	165	37	187	+0.2	+2.8
Nov 07 01:20	76081	RD	7.5	164	36	210	+1.8	+2.0
Nov 07 01:20	529	RD	6.1	164	36	287	+2.8	-0.3
Nov 08 22:44	864	RD	6.6	139	13	288	+1.6	-1.4
Nov 08 23:52	77506	RD	7.4	139	23	287	+2.2	-1.3
Nov 11 02:24	1181	RD	7.0	113	30	272	+2.3	-0.7
Nov 15 03:37	118636	RD	7.3	68	26	265	+1.6	-1.0
Nov 15 03:44	1609	DB	4.6	68	28	169	+0.7	-3.2
Nov 23 19:18	2583	DD	5.8	29	16	86	+0.1	+0.9
Nov 28 20:43	3325	DD	6.9	92	47	111	+3.0	-0.2
Nov 28 23:02	3333	DD	6.4	93	17	8	-0.3	+2.7
Dec 02 20:30	317	DD	6.4	146	44	100	+3.3	-0.8
Dec 04 21:32	616	DD	5.4	171	32	118	+3.3	-1.9
Dec 06 00:29	788	RD	6.8	170	33	264	+2.5	+0.3
Dec 06 00:56	77089	RD	7.3	170	33	232	+2.6	+1.4
Dec 06 04:27	810	DD	1.7	169	8	155	-0.7	-1.7
Dec 09 00:36	80089	RD	7.2	134	28	252	+2.1	-0.2
Dec 09 01:29	1251	RD	5.9	134	34	238	+3.0	+0.9
Dec 13 02:36	1668	RD	7.5	89	33	259	+2.1	-0.7
Dec 18 03:51	2183	DB	5.5	33	17	187	-1.9	-4.2
Dec 18 04:12	2183	RD	5.5	33	21	228	+2.0	+1.3
Dec 19 15:01	Antares	DB	1.1	18	30	32	-0.6	+4.0
Dec 19 15:36	Antares	RD	1.1	18	22	327	+1.6	-1.8
Dec 24 20:16	3157	DD	7.3	48	19	41	-0.1	+1.8
Dec 31 23:32	569	DD	5.3	141	25	148	+1.2	-3.0

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:34	3237	DD	4.3	46	5	354	-0.8	+3.1
Jan 08 22:16	92911	DD	7.5	111	22	140	+2.3	-2.3
Jan 10 21:04	76472	DD	7.2	135	29	129	+3.6	-1.6
Jan 10 23:00	616	DD	5.4	135	22	11	+2.3	+4.0
Jan 11 23:30	768	DD	7.0	147	22	144	+1.6	-1.3
Jan 12 23:35	77956	DD	7.5	158	25	121	+2.1	-0.4
Jan 14 02:34	1081	DD	6.5	170	14	99	+1.4	+0.8
Jan 21 00:04	1790	RD	6.9	112	20	295	+0.6	-1.8
Jan 22 03:06	1911	RD	7.3	100	50	15	-1.5	-4.6
Jan 26 03:43	2409	RD	7.0	52	29	259	+0.7	-0.8
Jan 27 03:09	2554	RD	4.5	39	12	279	-0.2	-1.1
Feb 05 20:40	438	DD	6.8	92	22	48	+1.6	+1.9
Feb 05 20:46	440	DD	4.7	92	21	116	+1.8	+0.3
Feb 05 20:46	X 54005	DD	5.6	92	21	117	+1.8	+0.3
Feb 05 21:40	440	RB	4.7	92	13	205	+1.5	+2.7
Feb 06 20:55	579	DD	6.4	104	23	32	+2.0	+2.3
Feb 07 20:46	76772	DD	7.2	116	25	16	+2.2	+3.3
Feb 07 21:29	76784	DD	7.5	116	22	47	+2.3	+1.8
Feb 09 21:35	1032	DD	5.4	139	26	100	+2.5	-0.2
Feb 11 20:29	80209	DD	7.1	160	20	140	+1.9	-2.3
Feb 11 22:22	1274	DD	5.7	161	30	180	+0.5	-3.9
Feb 11 22:55	1279	DD	6.4	161	31	133	+1.9	-1.2
Feb 13 01:10	1393	DD	6.5	172	33	120	+1.8	-0.4
Feb 13 22:15	1479	RD	6.4	175	29	272	+2.1	-1.1
Feb 14 21:50	1576	RD	5.3	165	24	255	+1.7	-0.9
Feb 18 23:14	158105	RD	7.5	121	23	296	+0.4	-1.8
Feb 19 01:04	1971	RD	5.5	121	45	346	+0.1	-2.9
Feb 22 01:26	2349	DB	2.9	85	27	84	+0.6	-1.0
Feb 22 02:21	2349	RD	2.9	85	38	322	0.0	-2.4
Feb 22 06:07	Antares	DB	1.1	83	80	98	+2.3	-0.5
Feb 22 07:35	Antares	RD	1.1	83	73	294	+2.2	-0.7
Feb 23 02:59	2505	DB	5.3	72	36	170	-1.3	-4.2
Feb 23 03:28	2505	RD	5.3	72	41	222	+2.6	+1.5
Mar 04 19:45	93033	DD	7.2	60	13	99	+1.0	+1.0
Mar 05 19:55	518	DD	6.0	72	15	68	+1.5	+1.5
Mar 06 18:29	673	DD	6.5	84	26	103	+2.5	+0.1
Mar 07 20:05	824	DD	6.2	96	22	103	+2.1	+0.4
Mar 08 20:50	78397	DD	7.6	108	23	116	+1.9	-0.1
Mar 09 22:11	1119	DD	5.8	120	22	175	-0.7	-2.8
Mar 09 22:19	1122	DD	3.8	120	21	107	+1.7	+0.4
Mar 09 23:38	1122	RB	3.8	120	12	298	+0.8	+0.3
Mar 10 00:08	1132	DD	6.4	120	8	101	+0.9	+0.8
Mar 13 00:45	1462	DD	7.3	154	31	109	+1.7	+0.2
Mar 16 21:53	138955	RD	7.2	163	35	330	+0.6	-2.4
Mar 18 02:11	158011	RD	7.1	151	66	315	+1.6	-1.7
Mar 21 01:13	2295	RD	7.2	116	50	274	+1.4	-1.2
Mar 22 23:29	2583	RD	5.8	92	10	293	-0.4	-1.4
Mar 23 03:34	2617	DB	4.6	90	56	74	+1.8	-0.3
Mar 23 03:57	186286	RD	7.1	90	61	314	+1.1	-2.9
Mar 23 04:49	2617	RD	4.6	90	71	298	+1.8	-1.9
Mar 24 01:57	2784	DB	3.3	78	25	129	-0.2	-2.2
Mar 24 02:23	187672	RD	7.4	78	30	326	-0.5	-3.4
Mar 24 02:48	2784	RD	3.3	78	35	235	+1.3	+0.2
Mar 26 02:59	3090	RD	6.7	51	11	304	-0.4	-2.4
Mar 26 03:00	3092	RD	6.3	51	12	219	+0.5	+0.5
Apr 04 19:16	921	DD	6.0	77	20	88	+2.0	+0.8
Apr 05 21:50	1081	DD	6.5	89	9	144	+0.1	-0.5
Apr 12 02:07	119114	DD	7.2	157	30	162	+0.4	-1.8
Apr 13 02:10	1814	DD	6.7	168	40	61	+3.2	+4.8
Apr 14 23:39	158333	RD	7.2	170	66	357	0.0	-3.7
Apr 14 23:40	2017	RD	6.4	170	66	305	+1.7	-1.8
Apr 15 23:48	158880	RD	7.5	158	64	284	+1.9	-1.2
Apr 16 00:38	2129	RD	7.4	158	72	319	+1.4	-2.2
Apr 16 19:58	2235	RD	6.3	148	12	286	-0.2	-1.3
Apr 17 04:33	2269	RD	5.4	145	59	321	+1.9	-1.8
Apr 18 00:06	2404	RD	6.7	134	51	298	+0.9	-1.9
Apr 18 21:47	185573	RD	6.8	123	14	259	+0.1	-0.8
Apr 20 04:14	2743	RD	7.6	107	77	320	+2.2	-4.1
Apr 22 00:48	189680	RD	7.4	83	12	259	+0.1	-0.8
Apr 23 02:49	164651	RD	7.6	69	22	255	+0.5	-0.7

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 02 17:14	1018	DD	5.8	57	24	128	+1.7	-0.4
May 04 19:15	1274	DD	5.7	80	27	124	+1.5	-0.3
May 04 20:13	1279	DD	6.4	81	22	81	+2.3	+1.4
May 06 19:56	1485	DD	7.1	103	39	154	+1.0	-1.6
May 07 18:46	1576	RB	5.3	113	42	308	+1.8	-1.6
May 12 00:07	1986	DD	7.1	160	61	105	+2.2	-0.1
May 13 02:27	2099	DD	6.9	172	47	138	+1.5	-1.1
May 14 19:39	2349	DB	2.9	165	23	100	+0.2	-1.3
May 14 20:38	2349	RD	2.9	165	34	304	+0.2	-1.9
May 15 00:12	Antares	DB	1.1	163	76	114	+1.9	-1.4
May 15 01:39	Antares	RD	1.1	163	78	281	+2.3	-0.3
May 15 02:54	2373	RD	6.1	163	65	278	+2.0	+0.3
May 15 20:35	185295	RD	7.4	153	24	346	-1.2	-3.4
May 17 00:34	186903	RD	7.7	138	59	330	+0.6	-4.5
May 20 05:49	164534	RD	7.3	97	72	299	+4.1	-2.7
Jun 03 19:51	99198	DD	7.3	83	35	110	+1.8	+0.1
Jun 06 23:22	1836	DD	6.3	118	34	167	+0.6	-2.4
Jun 10 20:42	2295	DD	7.2	164	60	119	+1.3	-1.8
Jun 11 03:53	2332	DD	6.1	166	28	61	+0.1	+2.1
Jun 12 22:26	2617	DB	4.6	169	59	136	+1.0	-2.9
Jun 12 22:49	186286	RD	7.1	169	64	252	+2.1	+0.1
Jun 12 23:27	2617	RD	4.6	168	71	234	+2.4	+1.4
Jun 13 02:14	186461	RD	7.4	167	71	276	+2.1	+0.3
Jun 13 04:31	2644	RD	6.4	167	44	221	+0.2	+2.7
Jun 13 04:35	186598	RD	7.5	167	43	322	+2.8	-2.1
Jun 13 20:49	187672	RD	7.4	157	28	235	+1.0	0.0
Jun 13 22:29	2796	RD	6.9	156	47	275	+1.2	-1.2
Jun 14 00:34	2805	RD	7.1	155	72	314	+2.1	-3.6
Jun 15 05:22	189244	RD	7.7	140	56	206	+0.3	+2.8
Jun 17 03:48	3268	DB	5.3	114	65	31	+1.2	+2.0
Jun 17 05:01	3268	RD	5.3	114	67	254	+2.1	+0.8
Jun 20 03:05	98	RD	6.0	74	21	271	+1.1	-1.3
Jun 22 04:16	375	RD	6.8	48	8	232	+0.2	0.0
Jun 30 18:23	1504	RB	5.4	53	29	323	+0.7	-0.9
Jul 01 20:02	118636	DD	7.3	65	24	131	+0.7	-0.4
Jul 01 21:00	1609	DD	4.6	65	14	132	+0.4	-0.3
Jul 03 22:01	1795	DD	6.9	87	24	96	+1.0	+1.1
Jul 04 17:53	1886	DD	5.6	97	63	166	+0.6	-3.0
Jul 04 19:06	1886	RB	5.6	97	62	278	+2.7	-0.1
Jul 06 22:48	2115	DD	7.2	121	49	73	+1.7	+2.2
Jul 07 21:02	2237	DD	5.0	133	78	89	+2.5	+0.2
Jul 07 22:24	2237	RB	5.0	133	65	312	+2.0	-1.4
Jul 07 22:50	183713	DD	7.4	133	61	171	+1.8	-5.8
Jul 08 00:05	2248	DD	7.6	134	46	157	+1.9	-2.8
Jul 09 00:43	2404	DD	6.7	146	51	39	+0.7	+4.0
Jul 09 19:59	185573	DD	6.8	157	57	67	+2.0	+0.1
Jul 09 20:37	2536	DD	7.7	158	64	141	+1.0	-3.1
Jul 10 05:17	2583	DD	5.8	161	11	119	+0.2	+0.3
Jul 12 20:09	3031	RD	5.9	161	20	309	-0.2	-2.8
Jul 12 22:32	3046	RD	7.1	160	48	283	+1.4	-1.7
Jul 12 23:22	3050	RD	7.4	160	58	273	+1.8	-1.0
Jul 13 06:15	3078	RD	4.9	157	29	229	+0.1	+1.8
Jul 13 20:34	3190	DB	2.9	147	11	54	+0.3	0.0
Jul 13 21:30	3190	RD	2.9	147	22	266	+0.5	-1.0
Jul 14 02:06	3210	RD	7.2	145	69	240	+1.8	+1.0
Jul 14 05:55	3224	RD	7.6	144	41	199	+0.1	+2.5
Jul 14 23:05	146296	RD	7.4	133	27	212	+0.7	+1.1
Jul 18 01:23	203	RD	6.8	91	13	241	+0.4	-0.2
Jul 20 04:05	470	RD	6.8	64	15	280	+1.6	-1.5
Jul 20 05:38	75832	RD	7.3	64	26	240	+1.4	+0.1
Jul 29 18:33	1668	DD	7.5	45	28	163	+0.3	-1.8
Aug 03 19:24	2183	DD	5.5	102	73	98	+2.4	0.0
Aug 03 20:50	2183	RB	5.5	102	57	307	+1.9	-0.9
Aug 04 19:52	184209	DD	7.7	114	79	98	+2.4	-0.2
Aug 05 22:00	2474	DD	6.7	127	68	28	+1.3	+6.0
Aug 06 17:55	2617	RB	4.6	138	48	241	+1.8	+0.2
Aug 06 19:12	186461	DD	7.4	139	63	56	+2.3	+0.9
Aug 06 20:48	186536	DD	7.5	139	80	139	+2.1	-3.5
Aug 06 21:52	2644	DD	6.4	140	80	69	+2.1	+1.2
Aug 08 03:16	2852	DD	7.3	155	29	12	-0.9	+3.1

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 08 21:17	189244	DD	7.7	166	61	80	+1.8	-0.3
Aug 09 00:31	189348	DD	7.6	167	71	63	+1.6	+1.4
Aug 09 02:50	189425	DD	7.5	168	44	42	+0.4	+2.1
Aug 10 19:32	3268	RD	5.3	166	13	244	+0.3	-0.3
Aug 11 01:23	3295	RD	7.0	163	66	272	+2.6	0.0
Aug 11 02:42	3307	DB	4.8	163	59	52	+1.3	+1.7
Aug 11 03:52	3307	RD	4.8	162	47	231	+0.9	+1.8
Aug 11 23:11	3430	RD	5.6	150	40	175	0.0	+3.8
Aug 12 00:43	3437	RD	6.8	149	54	192	+0.6	+2.4
Aug 12 22:48	19	RD	7.5	136	22	233	+0.6	+0.2
Aug 13 04:08	109127	RD	7.2	134	48	264	+2.3	+0.7
Aug 14 01:59	166	RD	6.7	121	39	218	+1.0	+1.0
Aug 16 02:57	438	RD	6.8	94	23	185	-0.5	+2.1
Aug 17 02:18	579	RD	6.4	82	7	267	+0.9	-1.0
Aug 31 21:44	2273	DD	5.9	84	33	140	+1.4	-1.0
Sep 03 00:33	2583	DD	5.8	109	23	36	-0.6	+2.5
Sep 03 21:26	2743	DD	7.6	121	71	78	+1.9	+1.1
Sep 05 18:50	3050	DD	7.4	147	47	40	+1.4	+1.2
Sep 06 01:46	3078	DD	4.9	149	40	71	+0.8	+1.5
Sep 06 03:47	3084	DD	6.7	151	16	354	-1.2	+3.3
Sep 06 17:44	3190	RB	2.9	160	20	256	+0.5	-0.6
Sep 06 20:51	3210	DD	7.2	162	55	60	+1.6	+0.5
Sep 07 00:43	164808	DD	7.7	163	59	41	+1.0	+2.0
Sep 07 00:59	3224	DD	7.6	163	57	95	+2.2	+0.6
Sep 08 00:29	Uranus	DB	5.7	177	61	90	+2.5	+0.3
Sep 08 01:24	Uranus	RD	5.7	178	56	189	+0.2	+1.0
Sep 08 23:13	146911	RD	7.1	168	50	244	+1.6	+0.4
Sep 09 03:33	128449	RD	7.6	167	37	248	+1.3	+1.5
Sep 13 01:22	518	RD	6.0	112	18	213	+0.4	+0.7
Sep 14 03:18	696	RD	7.5	99	22	239	+1.4	0.0
Sep 15 04:08	850	RD	6.0	86	20	207	+0.6	+1.3
Sep 16 04:28	1018	RD	5.8	74	16	245	+1.3	-0.3
Oct 02 20:22	189348	DD	7.6	115	76	39	+1.3	+2.3
Oct 02 22:58	189425	DD	7.5	116	48	16	-0.2	+3.0
Oct 04 22:10	3295	DD	7.0	143	65	45	+1.3	+1.7
Oct 05 00:35	3307	DD	4.8	144	44	85	+1.4	+1.2
Oct 05 01:30	3307	RB	4.8	144	33	202	+0.1	+2.3
Oct 07 00:03	109127	DD	7.2	172	50	43	+1.3	+1.5
Oct 07 21:50	166	RD	6.7	174	34	216	+0.7	+0.9
Oct 09 00:32	317	RD	6.4	159	37	198	+0.6	+1.7
Oct 13 02:08	948	RD	4.3	105	14	301	+2.1	-1.9
Oct 14 03:13	1103	RD	5.8	93	17	246	+1.4	-0.4
Oct 15 02:42	1233	RD	5.7	82	7	330	+1.8	-3.0
Oct 26 19:52	2474	DD	6.7	47	28	76	+0.3	+1.5
Oct 27 19:40	186434	DD	7.5	59	42	37	0.0	+2.9
Oct 27 19:52	186461	DD	7.4	59	39	94	+1.0	+1.0
Oct 27 22:08	186598	DD	7.5	60	14	67	-0.3	+1.4
Oct 27 22:09	2643	DD	6.7	60	13	19	-1.3	+2.9
Oct 28 20:56	2805	DD	7.1	72	38	107	+1.3	+0.6
Oct 30 19:19	3078	RB	4.9	96	72	284	+3.0	-0.5
Nov 03 00:02	128449	DD	7.6	139	36	67	+1.2	+1.5
Nov 04 22:26	244	DD	6.7	166	40	24	+0.8	+1.6
Nov 06 21:27	518	RD	6.0	165	16	244	+0.8	-0.3
Nov 07 00:58	76081	RD	7.5	164	30	196	+1.0	+2.1
Nov 07 01:11	529	RD	6.1	164	29	275	+2.4	+0.1
Nov 11 02:21	1181	RD	7.0	113	21	258	+1.9	-0.6
Nov 15 03:37	118636	RD	7.3	68	20	242	+1.6	-0.3
Nov 15 04:15	1609	DB	4.6	68	27	203	-1.7	-6.8
Nov 23 20:04	2583	RB	5.8	29	13	239	-0.4	+1.6
Nov 28 20:37	3325	DD	6.9	92	48	132	+8.3	-5.3
Nov 28 20:48	3325	RD	6.9	92	46	150	-5.9	+8.8
Nov 28 22:43	3333	DD	6.4	93	24	21	0.0	+2.3
Dec 02 20:27	317	DD	6.4	146	36	117	+3.9	-2.2
Dec 04 21:39	616	DD	5.4	171	24	141	+5.2	-4.8
Dec 04 22:01	616	RD	5.4	171	26	174	-1.9	+4.6
Dec 06 00:17	788	RD	6.8	170	26	251	+2.2	+0.3
Dec 06 00:35	77089	RD	7.3	170	26	214	+2.0	+1.6
Dec 09 00:29	80089	RD	7.2	134	19	232	+1.5	+0.2
Dec 19 14:38	Antares	DB	1.1	18	39	60	+0.6	+2.3
Dec 19 15:37	Antares	RD	1.1	18	27	302	+0.9	+0.1

LUNAR OCCULTATION TABLE

MELBOURNE (37° 50' S, 145° 00' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:30	3237	DD	4.3	46	9	358	-0.7	+2.8
Jan 10 20:53	76472	DD	7.2	135	26	128	+3.6	-1.7
Jan 10 22:44	616	DD	5.4	135	22	19	+1.9	+2.6
Jan 11 23:29	768	DD	7.0	147	21	157	+1.5	-2.8
Jan 12 23:28	77956	DD	7.5	158	23	128	+2.1	-0.7
Jan 14 02:27	1081	DD	6.5	170	15	111	+1.3	+0.5
Jan 21 00:06	1790	RD	6.9	112	16	289	+0.5	-1.8
Jan 22 03:18	1911	RD	7.3	100	48	355	0.0	-3.1
Jan 26 03:42	2409	RD	7.0	52	26	244	+0.8	-0.5
Jan 27 03:12	2554	RD	4.5	39	11	268	-0.2	-1.0
Feb 05 20:38	440	DD	4.7	92	22	121	+2.1	+0.1
Feb 05 20:38	X 54005	DD	5.6	92	22	121	+2.1	+0.1
Feb 05 21:26	440	RB	4.7	92	16	197	+1.5	+2.9
Feb 06 20:41	579	DD	6.4	104	23	36	+1.9	+1.8
Feb 07 20:31	76772	DD	7.2	116	24	22	+1.8	+2.2
Feb 07 21:16	76784	DD	7.5	116	22	52	+2.2	+1.4
Feb 09 21:26	1032	DD	5.4	139	23	105	+2.3	-0.5
Feb 11 20:27	80209	DD	7.1	160	15	144	+1.8	-2.4
Feb 11 22:51	1279	DD	6.4	161	28	143	+1.7	-1.5
Feb 12 00:57	1283	DD	7.0	162	25	68	+3.2	+1.7
Feb 13 01:04	1393	DD	6.5	172	31	133	+1.5	-0.8
Feb 13 22:10	1479	RD	6.4	175	24	264	+1.9	-1.1
Feb 14 21:46	1576	RD	5.3	165	19	246	+1.5	-0.7
Feb 18 23:16	158105	RD	7.5	121	21	288	+0.3	-1.7
Feb 19 01:10	1971	RD	5.5	121	42	333	+0.4	-2.5
Feb 19 05:58	1986	RD	7.1	119	57	286	+2.0	0.0
Feb 22 01:27	2349	DB	2.9	85	25	96	+0.3	-1.3
Feb 22 02:26	2349	RD	2.9	85	36	309	+0.2	-2.0
Feb 22 06:01	Antares	DB	1.1	83	75	111	+1.9	-1.2
Feb 22 07:28	Antares	RD	1.1	83	75	283	+2.2	-0.3
Mar 07 19:56	824	DD	6.2	96	21	109	+2.1	+0.1
Mar 08 20:43	78397	DD	7.6	108	22	125	+1.9	-0.3
Mar 09 22:11	1122	DD	3.8	120	21	118	+1.6	0.0
Mar 09 23:32	1122	RB	3.8	120	13	285	+1.2	+0.7
Mar 13 00:39	1462	DD	7.3	154	31	123	+1.4	-0.3
Mar 14 21:18	1645	DD	6.7	174	30	99	+1.6	-1.5
Mar 16 21:57	138955	RD	7.2	163	32	320	+0.6	-2.2
Mar 18 02:08	158011	RD	7.1	150	64	301	+1.9	-1.3
Mar 21 01:09	2295	RD	7.2	116	46	259	+1.5	-0.8
Mar 21 01:14	2299	RD	6.2	116	46	349	-0.6	-3.6
Mar 22 01:31	184921	RD	7.7	104	40	317	+0.1	-2.4
Mar 22 23:34	2583	RD	5.8	92	9	282	-0.4	-1.2
Mar 23 03:29	2617	DB	4.6	90	52	88	+1.4	-1.0
Mar 23 03:59	186286	RD	7.1	90	58	299	+1.2	-2.1
Mar 23 04:46	2617	RD	4.6	90	67	286	+1.7	-1.4
Mar 23 04:56	186346	RD	7.6	90	69	214	+2.9	+3.6
Mar 24 02:06	2784	DB	3.3	78	24	147	-0.7	-3.2
Mar 24 02:31	187672	RD	7.4	78	29	308	-0.1	-2.3
Mar 24 02:41	2784	RD	3.3	78	31	216	+1.5	+1.1
Apr 04 19:06	921	DD	6.0	77	20	97	+2.0	+0.5
Apr 10 23:20	118702	DD	7.5	145	42	60	+6.2	+4.6
Apr 12 02:12	119114	DD	7.2	157	30	181	-0.1	-3.1
Apr 13 01:52	1814	DD	6.7	168	44	85	+2.3	+1.5
Apr 14 23:37	2017	RD	6.4	170	62	291	+1.8	-1.4
Apr 14 23:45	158333	RD	7.2	170	62	339	+0.7	-2.8
Apr 15 23:42	158880	RD	7.5	158	59	268	+2.1	-0.8
Apr 16 00:37	2129	RD	7.4	158	67	304	+1.5	-1.8
Apr 17 00:17	2257	RD	6.7	146	58	354	-0.5	-4.3
Apr 17 04:29	2269	RD	5.4	145	62	310	+1.9	-1.1
Apr 18 00:06	2404	RD	6.7	134	48	285	+1.0	-1.5
Apr 18 21:48	185573	RD	6.8	123	12	247	+0.1	-0.6
Apr 18 23:30	2545	RD	6.4	122	30	354	-2.1	-5.3
Apr 20 04:14	2743	RD	7.6	107	72	305	+2.0	-2.5
Apr 23 02:48	164651	RD	7.6	69	19	244	+0.4	-0.4
May 04 19:11	1274	DD	5.7	80	26	137	+1.3	-0.7
May 04 20:02	1279	DD	6.4	81	22	97	+1.9	+0.7
May 05 21:56	1393	DD	6.5	92	18	70	+2.4	+2.5
May 06 19:58	1485	DD	7.1	103	37	170	+0.4	-2.2
May 07 18:42	1576	RB	5.3	113	38	298	+1.9	-1.5
May 11 19:46	1971	DD	5.5	158	42	59	+3.3	+0.5

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 12 00:00	1986	DD	7.1	160	62	120	+1.9	-0.8
May 14 19:42	2349	DB	2.9	165	21	111	0.0	-1.5
May 14 20:41	2349	RD	2.9	165	32	293	+0.3	-1.7
May 15 00:09	Antares	DB	1.1	163	71	128	+1.5	-2.1
May 15 01:30	Antares	RD	1.1	163	78	269	+2.3	+0.1
May 15 02:44	2373	RD	6.1	163	69	269	+2.1	+0.6
May 15 20:46	185295	RD	7.4	153	23	327	-0.6	-2.4
May 16 06:11	185573	RD	6.8	149	42	288	+1.3	+0.5
May 17 00:40	186903	RD	7.7	138	56	311	+1.0	-2.8
May 20 05:39	164534	RD	7.3	97	68	296	+3.5	-2.4
May 30 18:37	1103	DD	5.8	38	8	84	+1.3	+1.4
May 31 18:28	1233	DD	5.7	50	17	44	+5.0	+5.4
May 31 18:50	1233	RD	5.7	50	15	11	-2.9	-5.0
Jun 03 19:45	99198	DD	7.3	83	36	125	+1.5	-0.5
Jun 06 23:29	1836	DD	6.3	118	35	188	0.0	-5.0
Jun 10 20:42	2295	DD	7.2	164	57	133	+0.8	-2.2
Jun 11 03:46	2332	DD	6.1	166	33	66	+0.4	+2.1
Jun 11 06:25	2349	DD	2.9	167	5	73	-0.5	+1.3
Jun 12 20:32	2601	RD	6.8	169	34	336	-0.7	-3.6
Jun 12 22:33	2617	DB	4.6	169	57	156	+0.2	-4.8
Jun 12 22:39	186286	RD	7.1	169	58	237	+2.1	+0.7
Jun 12 23:12	2617	RD	4.6	168	64	216	+2.8	+3.0
Jun 13 01:14	186434	RD	7.5	168	80	327	+2.4	-4.4
Jun 13 02:04	186461	RD	7.4	167	75	270	+2.1	+0.4
Jun 13 04:23	2644	RD	6.4	167	50	219	+0.4	+2.9
Jun 13 04:29	186598	RD	7.5	167	48	320	+2.6	-1.8
Jun 13 20:44	187672	RD	7.4	157	24	217	+1.2	+0.8
Jun 13 21:24	187716	RD	7.2	157	32	335	-0.9	-4.5
Jun 13 22:27	2796	RD	6.9	156	44	262	+1.1	-0.8
Jun 14 00:34	2805	RD	7.1	155	67	300	+1.8	-2.3
Jun 15 05:13	189244	RD	7.7	140	60	207	+0.5	+2.8
Jun 17 03:38	3268	DB	5.3	114	59	32	+1.2	+1.7
Jun 17 04:50	3268	RD	5.3	114	65	255	+2.1	+0.6
Jun 18 06:00	3405	RD	7.0	100	58	264	+2.4	+0.4
Jun 20 03:04	98	RD	6.0	74	17	266	+0.8	-1.1
Jun 23 06:17	75990	RD	7.5	34	11	188	-0.7	+1.8
Jun 30 18:21	1504	RB	5.4	53	29	309	+1.1	-0.3
Jul 01 20:00	118636	DD	7.3	65	26	145	+0.6	-0.8
Jul 01 20:59	1609	DD	4.6	65	16	145	+0.3	-0.7
Jul 03 21:55	1795	DD	6.9	87	28	108	+1.0	+0.6
Jul 04 18:01	1886	DD	5.6	97	60	185	-0.4	-4.0
Jul 04 18:52	1886	RB	5.6	97	61	258	+3.6	+1.0
Jul 06 22:36	2115	DD	7.2	121	54	85	+1.9	+1.3
Jul 07 20:53	2237	DD	5.0	133	76	103	+2.2	-0.7
Jul 07 22:19	2237	RB	5.0	133	68	301	+2.0	-0.9
Jul 08 00:07	2248	DD	7.6	134	49	172	+2.2	-6.0
Jul 09 00:30	2404	DD	6.7	146	56	48	+1.2	+3.2
Jul 09 19:53	185573	DD	6.8	157	52	82	+1.5	-0.7
Jul 10 05:15	2583	DD	5.8	161	15	119	+0.3	+0.4
Jul 12 20:15	3031	RD	5.9	161	19	292	0.0	-1.9
Jul 12 22:30	3046	RD	7.1	160	44	272	+1.2	-1.2
Jul 12 23:17	3050	RD	7.4	160	53	265	+1.6	-0.7
Jul 13 05:08	3078	DB	4.9	158	46	68	+0.9	+1.6
Jul 13 06:10	3078	RD	4.9	157	34	230	+0.3	+1.8
Jul 13 20:33	3190	DB	2.9	147	8	67	+0.1	-0.5
Jul 13 21:30	3190	RD	2.9	147	19	255	+0.4	-0.7
Jul 14 01:56	3210	RD	7.2	145	65	238	+1.7	+0.9
Jul 14 05:44	164808	RD	7.7	144	46	255	+1.2	+1.4
Jul 14 05:48	3224	RD	7.6	144	45	202	+0.2	+2.4
Jul 14 22:59	146296	RD	7.4	133	22	201	+0.6	+1.5
Jul 16 06:02	146911	RD	7.1	116	48	219	+1.1	+1.8
Jul 20 05:33	75832	RD	7.3	64	21	242	+1.2	-0.1
Jul 29 18:39	1668	DD	7.5	45	28	182	-0.2	-3.1
Aug 03 19:16	2183	DD	5.5	102	73	111	+2.1	-0.8
Aug 03 20:44	2183	RB	5.5	102	61	296	+1.9	-0.4
Aug 04 19:45	184209	DD	7.7	114	78	110	+2.1	-0.9
Aug 05 20:42	2470	DD	6.1	126	80	43	+2.6	+3.5
Aug 05 21:41	2474	DD	6.7	127	73	42	+1.9	+3.7
Aug 06 17:46	2617	RB	4.6	138	43	221	+2.1	+1.3
Aug 06 19:03	186461	DD	7.4	139	57	71	+1.8	-0.1

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 06 20:53	186536	DD	7.5	139	77	160	+1.6	-7.6
Aug 06 21:41	2644	DD	6.4	140	80	77	+2.1	+0.6
Aug 08 03:12	2852	DD	7.3	155	33	11	-0.9	+3.3
Aug 08 21:12	189244	DD	7.7	166	56	89	+1.6	-0.9
Aug 09 00:21	189348	DD	7.6	167	73	64	+1.7	+1.3
Aug 09 02:43	189425	DD	7.5	168	49	40	+0.5	+2.2
Aug 10 19:31	3268	RD	5.3	166	10	232	+0.2	0.0
Aug 11 01:13	3295	RD	7.0	163	63	273	+2.5	-0.3
Aug 11 02:33	3307	DB	4.8	163	60	49	+1.3	+1.6
Aug 11 03:43	3307	RD	4.8	162	50	233	+1.1	+1.7
Aug 11 22:59	3430	RD	5.6	150	34	164	-0.6	+6.4
Aug 12 00:35	3437	RD	6.8	149	49	191	+0.5	+2.3
Aug 12 22:45	19	RD	7.5	136	18	227	+0.4	+0.2
Aug 13 03:56	109127	RD	7.2	134	47	268	+2.4	+0.4
Aug 14 01:53	166	RD	6.7	121	34	219	+0.8	+0.8
Aug 14 03:23	173	RD	6.5	120	41	164	-1.3	+3.9
Aug 16 02:54	438	RD	6.8	94	19	186	-0.5	+1.9
Aug 31 21:41	2273	DD	5.9	84	37	147	+1.6	-1.5
Sep 03 00:29	2583	DD	5.8	109	28	36	-0.5	+2.6
Sep 03 21:16	2743	DD	7.6	121	75	82	+2.0	+0.7
Sep 06 01:38	3078	DD	4.9	149	45	69	+0.9	+1.5
Sep 06 03:44	3084	DD	6.7	151	20	353	-1.3	+3.4
Sep 06 20:44	3210	DD	7.2	162	50	66	+1.4	+0.1
Sep 07 00:34	164808	DD	7.7	163	61	39	+1.0	+2.0
Sep 07 00:49	3224	DD	7.6	163	59	92	+2.1	+0.6
Sep 08 00:19	Uranus	DD	5.7	177	60	87	+2.3	+0.2
Sep 08 01:16	Uranus	RB	5.7	178	56	192	+0.4	+2.5
Sep 08 23:06	146911	RD	7.1	168	45	244	+1.4	+0.2
Sep 09 03:24	128449	RD	7.6	167	40	250	+1.4	+1.4
Sep 10 02:31	105	DB	4.4	153	44	122	+4.9	-2.2
Sep 10 02:54	105	RD	4.4	153	43	159	-1.9	+4.5
Sep 13 01:19	518	RD	6.0	112	14	214	+0.3	+0.5
Sep 13 05:25	529	RD	6.1	111	26	247	+2.0	+0.8
Sep 14 03:13	696	RD	7.5	99	17	240	+1.2	-0.2
Sep 15 04:03	850	RD	6.0	86	15	208	+0.4	+1.0
Sep 16 04:24	1018	RD	5.8	74	12	244	+1.1	-0.5
Sep 30 21:16	186903	DD	7.7	90	51	44	+0.5	+2.6
Oct 01 22:00	188263	DD	7.7	102	53	47	+0.7	+2.2
Oct 02 20:11	189348	DD	7.6	115	75	41	+1.4	+2.1
Oct 02 22:51	189425	DD	7.5	116	52	14	-0.1	+3.1
Oct 04 22:01	3295	DD	7.0	143	63	44	+1.3	+1.6
Oct 05 00:26	3307	DD	4.8	144	47	82	+1.5	+1.2
Oct 05 01:23	3307	RB	4.8	144	37	204	+0.2	+2.2
Oct 06 23:55	109127	DD	7.2	172	48	40	+1.2	+1.4
Oct 07 21:45	166	RD	6.7	174	29	215	+0.6	+0.8
Oct 09 00:26	317	RD	6.4	158	34	201	+0.6	+1.4
Oct 13 02:05	948	RD	4.3	105	10	301	+1.9	-1.9
Oct 14 03:09	1103	RD	5.8	93	12	244	+1.2	-0.5
Oct 27 22:05	186598	DD	7.5	60	18	67	-0.2	+1.5
Oct 27 22:07	2643	DD	6.7	60	18	18	-1.2	+3.1
Oct 28 20:49	2805	DD	7.1	72	43	106	+1.4	+0.6
Oct 30 19:09	3078	RB	4.9	96	72	284	+2.8	-0.6
Nov 02 23:53	128449	DD	7.6	139	39	65	+1.3	+1.5
Nov 04 22:19	244	DD	6.7	166	37	21	+0.7	+1.5
Nov 06 21:25	518	RD	6.0	165	11	244	+0.7	-0.4
Nov 07 00:49	76081	RD	7.5	164	27	197	+0.8	+1.7
Nov 07 01:01	529	RD	6.1	164	27	276	+2.3	-0.1
Nov 08 03:54	76772	RD	7.2	150	19	246	+1.9	+1.2
Nov 11 02:15	1181	RD	7.0	113	16	255	+1.6	-0.7
Nov 15 03:31	118636	RD	7.3	68	15	229	+1.4	+0.5
Nov 23 20:02	2583	RB	5.8	29	18	239	-0.3	+1.7
Nov 28 22:37	3333	DD	6.4	93	28	20	+0.1	+2.4
Dec 04 21:32	616	DD	5.4	171	19	137	+4.1	-3.9
Dec 04 21:57	616	RD	5.4	172	22	178	-1.3	+3.3
Dec 06 00:08	788	RD	6.8	170	23	250	+1.9	+0.2
Dec 06 00:24	77089	RD	7.3	170	23	210	+1.6	+1.4
Dec 06 03:31	801	RD	6.5	169	13	248	+1.7	+1.5
Dec 08 01:16	1119	RD	5.8	146	22	349	+2.0	-3.4
Dec 19 14:29	Antares	DB	1.1	18	45	65	+0.9	+2.2
Dec 19 15:32	Antares	RD	1.1	18	32	299	+1.0	+0.3

LUNAR OCCULTATION TABLE

PERTH (31° 57' S, 115° 51' E)

WST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 06 22:50	98	DD	6.0	87	11	11	+0.4	+2.8
Jan 07 21:07	230	DD	7.3	99	34	40	+1.4	+2.0
Jan 09 20:37	75845	DD	7.6	124	35	40	+1.7	+1.4
Jan 10 21:39	76514	DD	7.2	136	32	106	+2.9	-0.3
Jan 13 23:33	1081	DD	6.5	170	30	135	+2.3	-1.4
Jan 16 04:19	1334	RD	7.0	164	23	231	+5.2	+5.6
Jan 18 01:08	99123	RD	7.3	144	38	331	+1.4	-2.3
Jan 18 02:51	99149	RD	7.1	143	45	340	+1.0	-2.2
Jan 19 01:58	118702	RD	7.5	133	44	277	+2.6	-1.1
Jan 22 00:55	1911	RD	7.3	100	22	318	+0.2	-2.1
Jan 25 03:40	2270	DB	5.4	64	34	91	+0.8	-1.1
Jan 26 03:20	2420	RD	7.5	51	20	267	+0.3	-0.9
Jan 26 04:03	184724	RD	7.5	51	29	267	+0.6	-0.9
Jan 27 04:29	2583	RD	5.8	37	22	273	+0.2	-1.0
Feb 08 23:11	77721	DD	7.6	129	21	115	+1.6	+0.1
Feb 11 02:09	1181	DD	7.0	152	14	161	-0.4	-1.5
Feb 11 21:37	1283	DD	7.0	162	28	100	+2.3	-1.0
Feb 11 23:53	1290	DD	6.9	162	34	115	+2.3	-0.6
Feb 12 22:13	1393	DD	6.5	172	31	170	+1.3	-3.3
Feb 18 22:49	1971	RD	5.5	120	15	305	0.0	-1.8
Feb 19 01:40	158190	RD	7.5	119	50	322	+0.8	-2.3
Feb 22 00:16	2349	RD	2.9	85	10	280	-0.2	-1.1
Feb 22 03:15	Antares	DB	1.1	83	45	142	+0.2	-2.5
Feb 22 04:21	Antares	RD	1.1	83	59	265	+2.0	-0.6
Feb 23 02:01	2512	RD	7.5	71	20	351	-1.7	-3.9
Feb 26 05:03	189613	RD	7.2	30	17	267	+0.2	-0.9
Mar 05 19:49	76046	DD	7.1	73	21	81	+1.7	+1.2
Mar 06 20:29	696	DD	7.5	86	20	51	+2.2	+2.0
Mar 09 20:30	1122	RB	3.8	120	30	252	+3.0	+0.5
Mar 09 21:30	1132	DD	6.4	121	29	153	+1.2	-1.7
Mar 10 20:53	1252	DD	7.3	131	32	41	+5.4	+3.7
Mar 11 01:10	1263	DD	6.9	133	13	63	+2.3	+2.8
Mar 12 21:53	1462	DD	7.3	154	40	171	+0.8	-2.8
Mar 13 01:32	98897	DD	7.6	155	30	181	-0.6	-2.9
Mar 17 22:53	158011	RD	7.1	151	40	241	+3.3	+0.6
Mar 18 02:42	1957	RD	7.7	149	69	346	+0.8	-3.2
Mar 18 04:54	158085	RD	7.3	149	49	273	+2.0	+0.9
Mar 20 23:06	2299	RD	6.2	116	20	308	-0.2	-1.7
Mar 21 03:46	184209	RD	7.7	114	77	240	+3.6	+1.9
Mar 23 01:02	2617	DB	4.6	90	22	115	-0.1	-1.6
Mar 23 01:27	186286	RD	7.1	90	27	274	+0.4	-1.1
Mar 23 02:02	2617	RD	4.6	90	34	266	+0.8	-0.9
Mar 24 01:29	2796	RD	6.9	77	15	337	-1.5	-3.9
Apr 02 18:08	616	DD	5.4	53	22	116	+1.7	+0.1
Apr 04 19:44	78095	DD	7.5	78	22	81	+2.2	+1.0
Apr 06 19:37	1213	DD	7.1	101	32	72	+3.3	+0.8
Apr 09 19:26	99123	DD	7.3	134	35	70	+3.2	0.0
Apr 10 19:54	118702	DD	7.5	145	38	121	+1.7	-1.8
Apr 12 01:09	119138	DD	7.4	157	45	135	+1.3	-1.0
Apr 12 02:16	1730	DD	6.2	158	33	166	+0.4	-2.2
Apr 12 22:44	1814	DD	6.7	168	60	131	+1.7	-1.8
Apr 14 21:08	158333	RD	7.2	170	37	296	+0.8	-1.7
Apr 15 21:45	2129	RD	7.4	158	37	260	+1.4	-0.8
Apr 16 21:59	2257	RD	6.7	146	31	309	+0.1	-1.9
Apr 17 01:23	2269	RD	5.4	145	73	301	+1.8	-1.8
Apr 17 04:25	2286	RD	5.4	144	65	330	+2.1	-2.9
Apr 17 21:38	2404	RD	6.7	134	18	249	+0.5	-0.5
Apr 17 22:22	2409	RD	7.0	134	26	319	-0.3	-2.1
Apr 19 05:39	2586	RD	6.0	119	74	231	+1.9	+2.6
Apr 20 01:24	2743	RD	7.6	107	40	300	+0.5	-2.1
May 05 18:54	1393	DD	6.5	92	38	121	+2.2	-0.9
May 07 00:04	1504	DD	5.4	105	11	148	0.0	-0.9
May 11 19:58	158190	DD	7.5	159	46	82	+2.2	-0.8
May 11 21:08	1986	DD	7.1	160	60	162	+0.5	-2.9
May 14 03:38	2237	RD	5.0	173	48	286	+1.6	+0.3
May 14 18:32	2349	RD	2.9	165	6	265	-0.2	-0.8
May 14 21:38	Antares	DB	1.1	163	42	168	-0.7	-3.6
May 14 22:19	Antares	RD	1.1	163	51	239	+2.6	+0.6
May 14 23:36	2373	RD	6.1	163	67	262	+2.4	-0.3
May 15 20:42	2512	RD	7.5	151	20	319	-0.5	-2.1
May 16 03:58	2536	RD	7.7	149	69	257	+2.0	+1.2
May 19 03:59	189613	RD	7.2	110	71	246	+2.1	+0.7
May 19 05:57	189680	RD	7.4	109	77	231	+1.6	+1.8
May 20 05:12	164583	RD	7.2	96	70	235	+1.9	+1.2
May 23 03:52	32	RD	7.0	57	16	188	0.0	+2.2
Jun 03 22:23	1562	DD	7.1	85	17	165	-0.1	-1.8
Jun 04 18:06	1644	DD	4.1	95	51	112	+2.4	-1.2
Jun 04 19:29	1644	RB	4.1	95	51	337	+1.0	-2.1
Jun 05 21:53	138591	DD	7.6	107	44	123	+1.5	-0.5
Jun 08 02:16	158085	DD	7.3	131	15	104	+0.4	+0.6
Jun 10 00:20	2183	DD	5.5	154	62	172	+1.5	-5.3
Jun 10 18:26	2299	DD	6.2	164	29	88	+0.7	-1.0
Jun 12 22:12	186434	RD	7.5	168	52	330	+0.3	-3.9
Jun 12 22:59	186461	RD	7.4	167	62	285	+1.7	-1.3
Jun 13 01:48	2644	RD	6.4	167	81	274	+2.4	+0.1
Jun 13 20:02	2796	RD	6.9	156	14	240	+0.4	-0.2
Jun 13 21:49	2805	RD	7.1	155	35	296	+0.4	-1.9
Jun 15 02:34	189244	RD	7.7	140	78	271	+2.5	-0.3
Jun 15 05:53	189348	RD	7.6	139	54	268	+1.6	+0.9
Jun 18 03:50	3412	DB	4.2	100	52	89	+2.3	-0.7
Jun 18 04:51	3412	RD	4.2	99	61	191	+0.6	+2.7
Jul 01 18:40	1609	DD	4.6	65	42	176	0.0	-2.8
Jul 01 19:30	118658	DD	7.3	65	35	164	+0.3	-2.0
Jul 01 19:37	1609	RB	4.6	65	33	267	+2.1	+1.4
Jul 03 19:08	1795	DD	6.9	87	58	130	+1.8	-1.3
Jul 04 22:45	1908	DD	6.9	99	31	193	+0.3	-8.1
Jul 06 00:54	158363	DD	7.3	112	16	159	+0.9	-2.0
Jul 06 19:26	2115	DD	7.2	121	75	103	+2.4	-1.0
Jul 07 19:13	2237	RB	5.0	133	66	282	+2.0	-1.1
Jul 07 20:56	2248	DD	7.6	134	82	156	+1.3	-3.5
Jul 08 02:21	2269	DD	5.4	136	22	64	0.0	+2.0
Jul 10 03:12	2583	DD	5.8	161	37	59	+0.3	+1.9
Jul 10 19:25	2723	DD	6.6	171	33	26	+2.6	+3.1
Jul 12 05:45	2934	RD	7.6	169	29	292	+1.1	+0.4
Jul 12 20:42	3050	RD	7.4	160	22	274	+0.4	-1.2
Jul 13 03:12	3078	DD	4.9	157	70	341	-3.5	+8.6
Jul 13 03:30	3078	RD	4.9	157	66	313	+6.4	-4.9
Jul 13 23:03	3210	RD	7.2	145	37	288	+1.2	-2.1
Jul 14 00:40	3217	RD	7.4	144	56	242	+1.7	+0.5
Jul 14 03:19	3224	RD	7.6	143	71	274	+2.8	0.0
Jul 14 05:11	3237	DB	4.3	143	54	99	+2.4	+0.5
Jul 14 05:58	3237	RD	4.3	142	45	186	-0.3	+3.0
Jul 29 19:27	1678	DD	5.8	47	23	156	+0.3	-1.5
Aug 03 17:36	2183	RB	5.5	102	72	280	+2.3	-1.0
Aug 05 02:33	Antares	DD	1.1	117	6	96	-0.2	+0.8
Aug 05 23:55	2505	DD	5.3	128	49	85	+1.3	+1.1
Aug 06 18:41	2644	DD	6.4	140	53	74	+1.8	-0.2
Aug 06 21:16	2660	DD	6.2	140	84	95	+2.4	-0.4
Aug 10 03:32	3171	DB	3.7	175	49	110	+2.5	0.0
Aug 10 04:09	3171	RB	3.7	175	41	179	-0.7	+3.3
Aug 11 01:20	3310	RD	6.4	162	69	234	+1.7	+1.3
Aug 11 21:01	3430	RD	5.6	150	12	217	+0.3	+0.7
Aug 11 22:14	3437	RD	6.8	149	27	247	+0.8	-0.2
Aug 13 23:21	166	RD	6.7	121	12	287	+1.0	-2.1
Aug 13 23:34	109700	RD	7.3	121	15	233	+0.4	+0.2
Aug 14 01:11	173	RD	6.5	120	32	249	+1.3	-0.1
Aug 15 04:07	317	RD	6.4	105	40	232	+1.6	+0.8
Aug 28 16:04	Spica	MD	1.0	49	67	41	+1.6	-2.1
Aug 30 21:38	2157	DD	6.1	73	26	145	+1.2	-1.2
Aug 31 19:24	2268	RB	4.5	84	65	243	+2.3	+2.5
Sep 04 01:33	187672	DD	7.4	123	26	126	+1.3	-0.3
Sep 04 02:18	187716	DD	7.2	124	17	54	-0.3	+1.6
Sep 05 23:40	3078	DD	4.9	150	69	346	-2.0	+6.3
Sep 06 00:05	3078	RB	4.9	150	64	306	+4.7	-2.6
Sep 06 19:30	3217	DD	7.4	162	37	71	+1.1	-0.3
Sep 06 22:10	3224	DD	7.6	163	67	19	+1.0	+2.6
Sep 07 01:04	3237	DD	4.3	165	60	105	+2.9	-0.1
Sep 07 01:46	3237	RB	4.3	165	52	178	-0.5	+3.4
Sep 07 02:31	3245	DD	6.9	165	43	79	+1.2	+1.3
Sep 07 21:42	Uranus	DD	5.7	177	48	17	+0.7	+2.2
Sep 07 22:41	Uranus	RB	5.7	178	58	268	+2.3	-0.5
Sep 09 00:35	3520	RD	5.8	167	57	211	+1.1	+1.7
Sep 09 23:33	105	DB	4.4	153	39	33	+0.8	+1.1
Sep 10 00:08	103	RD	5.9	152	44	214	+0.9	+1.2
Sep 10 00:42	105	RD	4.4	152	47	244	+1.8	+0.5
Sep 10 01:22	109488	RD	7.6	152	50	210	+1.0	+1.6
Sep 10 23:01	92574	RD	7.6	139	21	222	+0.4	+0.5
Sep 13 01:09	76046	RD	7.1	111	16	220	+0.3	+0.5
Sep 13 02:28	76081	RD	7.5	111	26	226	+1.0	+0.5
Sep 15 03:36	864	RD	6.6	85	17	221	+0.6	+0.6
Sep 15 04:54	77506	RD	7.4	85	25	224	+1.5	+0.8
Sep 16 05:20	1032	RD	5.4	73	23	273	+2.1	-0.8
Sep 26 20:25	182937	DD	7.6	43	15	105	+0.3	+0.6
Sep 27 20:11	183713	DD	7.4	55	29	84	+0.6	+1.3
Sep 27 21:21	2248	DD	7.6	55	16	91	+0.1	+1.0
Sep 29 22:38	185573	DD	6.8	79	23	18	-1.4	+4.0
Oct 02 22:02	3009	DD	7.4	117	63	96	+2.3	+0.4
Oct 04 22:02	3307	DD	4.8	144	69	8	+0.4	+3.0
Oct 04 22:05	3310	DD	6.4	144	69	83	+2.5	+0.4
Oct 04 22:59	3307	RB	4.8	144	64	271	+2.6	+0.4
Oct 05 03:16	3325	DD	6.9	146	15	92	+0.4	+1.0
Oct 07 21:00	173	RD	6.5	173	26	246	+0.9	-0.1
Oct 08 21:54	317	RD	6.4	158	21	275	+1.5	-1.2
Oct 09 03:13	336	RD	7.4	156	33	243	+1.8	+1.3
Oct 10 00:31	470	RD	6.8	144	30	169	-2.0	+4.4
Oct 10 04:35	483	RD	7.5	142	26	189	+1.6	+3.5
Oct 11 02:46	638	DB	5.0	129	30	82	+2.3	0.0
Oct 11 04:09	76557	RD	7.4	129	30	244	+2.2	+0.9
Oct 11 04:11	638	RD	5.0	129	30	244	+2.2	+0.9
Oct 11 04:40	76563	RD	7.2	129	28	234	+2.2	+1.4
Oct 12 01:01	788	RD	6.8	117	14	248	+0.9	-0.3
Oct 12 01:11	77089	RD	7.3	117	15	201	-0.2	+1.5
Oct 13 02:25	967	RD	7.0	104	17	291	+2.0	-1.5
Oct 14 04:56	1122	DB	3.8	92	28	68	+2.5	+0.1
Oct 14 05:41	1119	RD	5.8	91	30	268	+2.7	-0.2
Oct 15 04:38	80070	RD	7.5	80	24	277	+2.0	-1.1
Oct 27 19:47	2644	DD	6.4	60	43	98	+1.3	+0.7
Oct 28 22:32	2824	DD	7.3	73	21	33	-0.5	+2.2
Oct 31 19:26	3237	DD	4.3	111	71	82	+2.5	+0.2
Oct 31 20:34	3237	RB	4.3	111	69	200	+0.7	+2.7
Oct 31 21:16	3245	DD	6.9	111	62	64	+1.7	+1.5
Nov 01 20:48	3379	DD	6.2	125	65	103	+3.6	-0.7
Nov 01 21:47	3383	DD	6.2	125	60	60	+1.7	+1.5
Nov 02 21:38	128449	DD	7.6	139	57	352	-0.5	+3.5
Nov 03 21:48	105	DD	4.4	153	50	81	+2.4	+0.2
Nov 03 22:52	105	RB	4.4	153	50	196	+0.7	+2.2
Nov 04 19:58	92574	DD	7.6	166	26	96	+1.7	-1.3
Nov 06 22:17	76081	RD	7.5	164	22	262	+1.5	-0.6
Nov 06 23:25	76102	RD	7.5	164	29	221	+1.1	+0.8
Nov 07 03:10	569	RD	5.3	162	25	200	+2.0	+2.9
Nov 08 00:56	76772	RD	7.2	150	28	267	+2.2	-0.3
Nov 08 01:47	76784	RD	7.5	150	30	240	+2.1	+0.6
Nov 09 02:12	77721	RD	7.6	137	28	224	+2.0	+1.1
Nov 11 03:33	1196	RD	7.6	112	29	315	+2.2	-1.7
Nov 16 03:26	1712	DB	3.6	56	11	49	+1.0	+1.1
Nov 16 03:46	1712	RD	3.6	56	15	14	-0.3	-4.9
Nov 23 19:59	NGC6520	DD	9.0	30	17	68	-0.2	+1.4
Nov 26 22:53	164087	DD	7.0	68	11	23	-0.6	+2.1
Nov 28 23:01	3346	DD	7.4	94	24	116	+1.4	+0.2
Dec 01 23:12	197	DD	7.0	134	35	3	+0.6	+3.0
Dec 02 22:48	336	DD	7.4	148	38	68	+2.1	+1.0
Dec 04 01:08	483	DD	7.5	162	25	114	+1.9	+0.1
Dec 06 00:35	801	RD	6.5	169	29	244	+2.3	+0.6
Dec 07 02:15	78431	RD	7.5	157	29	240	+2.8	+1.1
Dec 08 00:42	79402	RD	7.3	145	25	300	+2.2	-1.5
Dec 08 03:23	79479	RD	7.2	144	30	324	+1.5	-1.3
Dec 09 01:16	80165	RD	7.5	133	25	282	+2.0	-1.1
Dec 12 02:57	1580	RD	7.6	99	32	319	+1.3	-2.2
Dec 13 02:41	118917	RD	7.3	88	26	263	+1.5	-1.1
Dec 27 22:46	30	DD	7.1	89	15	52	+0.6	+1.8

LUNAR OCCULTATION TABLE

SYDNEY (33° 54' S, 151° 15' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 08 22:18	92911	DD	7.5	111	21	135	+1.9	-1.3
Jan 10 21:09	76472	DD	7.2	135	30	128	+3.5	-1.5
Jan 10 23:12	616	DD	5.4	135	20	2	+3.0	+7.0
Jan 11 23:32	768	DD	7.0	147	22	138	+1.6	-0.9
Jan 12 23:39	77956	DD	7.5	158	25	117	+2.1	-0.2
Jan 14 02:38	1081	DD	6.5	170	14	92	+1.4	+1.0
Jan 21 00:02	1790	RD	6.9	112	22	299	+0.6	-1.9
Jan 26 03:43	2409	RD	7.0	52	31	266	+0.7	-1.0
Jan 27 03:07	2554	RD	4.5	39	13	285	-0.2	-1.2
Feb 05 20:46	438	DD	6.8	92	21	46	+1.6	+2.0
Feb 05 20:50	440	DD	4.7	92	21	114	+1.6	+0.4
Feb 05 20:50	X 54005	DD	5.6	92	21	114	+1.6	+0.4
Feb 06 19:55	574	DD	6.8	104	29	134	+3.1	-1.6
Feb 06 21:02	579	DD	6.4	104	22	28	+2.1	+2.6
Feb 07 20:57	76772	DD	7.2	116	25	10	+2.6	+4.8
Feb 07 21:37	76784	DD	7.5	116	22	42	+2.4	+2.2
Feb 07 23:06	731	DD	6.0	116	11	170	-3.0	-7.0
Feb 09 21:40	1032	DD	5.4	139	27	96	+2.5	0.0
Feb 11 20:30	80209	DD	7.1	160	22	138	+2.0	-2.2
Feb 11 22:19	1274	DD	5.7	161	31	171	+1.0	-3.0
Feb 11 22:58	1279	DD	6.4	161	32	128	+2.0	-1.0
Feb 13 01:13	1393	DD	6.5	172	33	113	+1.9	-0.1
Feb 13 22:18	1479	RD	6.4	175	32	277	+2.2	-1.2
Feb 14 21:53	1576	RD	5.3	165	26	260	+1.8	-1.0
Feb 18 23:12	158105	RD	7.5	121	25	301	+0.4	-1.8
Feb 19 01:00	1971	RD	5.5	121	46	354	-0.2	-3.2
Feb 22 01:26	2349	DB	2.9	85	29	77	+0.8	-0.8
Feb 22 02:17	2349	RD	2.9	85	39	330	-0.1	-2.6
Feb 22 06:12	Antares	DB	1.1	83	82	91	+2.5	-0.1
Feb 22 07:39	Antares	RD	1.1	83	71	299	+2.2	-0.9
Feb 23 02:52	2505	DB	5.3	72	36	157	-0.6	-3.2
Feb 23 03:34	2505	RD	5.3	72	44	235	+2.1	+0.5
Mar 04 19:48	93033	DD	7.2	60	11	96	+0.9	+1.0
Mar 05 20:00	518	DD	6.0	72	14	65	+1.5	+1.6
Mar 07 20:10	824	DD	6.2	96	22	99	+2.0	+0.5
Mar 09 22:07	1119	DD	5.8	120	23	163	+0.1	-1.8
Mar 09 22:23	1122	DD	3.8	120	21	100	+1.8	+0.6
Mar 09 23:40	1122	RB	3.8	120	11	305	+0.6	+0.1
Mar 13 00:50	1462	DD	7.3	154	30	100	+1.9	+0.6
Mar 16 21:51	138955	RD	7.2	163	37	335	+0.5	-2.5
Mar 18 02:12	158011	RD	7.1	151	67	323	+1.5	-2.0
Mar 21 01:14	2295	RD	7.2	116	52	281	+1.4	-1.4
Mar 22 23:27	2583	RD	5.8	92	10	299	-0.5	-1.5
Mar 23 03:38	2617	DB	4.6	90	59	67	+2.1	+0.2
Mar 23 03:55	186286	RD	7.1	90	62	323	+1.0	-3.6
Mar 23 04:50	2617	RD	4.6	90	74	305	+1.9	-2.3
Mar 24 01:54	2784	DB	3.3	78	26	121	0.0	-1.9
Mar 24 02:15	187672	RD	7.4	78	30	341	-1.4	-5.4
Mar 24 02:51	2784	RD	3.3	78	37	243	+1.2	-0.1
Mar 26 02:54	3090	RD	6.7	51	11	315	-0.7	-3.3
Mar 26 03:02	3092	RD	6.3	51	13	227	+0.5	+0.3
Apr 04 19:21	921	DD	6.0	77	20	83	+2.0	+1.0
Apr 12 02:06	119114	DD	7.2	157	29	154	+0.5	-1.4
Apr 14 19:33	2002	RD	6.8	171	22	267	+0.6	-1.2
Apr 14 23:41	2017	RD	6.4	170	68	313	+1.5	-2.0
Apr 15 23:50	158880	RD	7.5	158	67	291	+1.9	-1.5
Apr 16 00:37	2129	RD	7.4	158	74	327	+1.2	-2.6
Apr 16 19:56	2235	RD	6.3	148	12	290	-0.2	-1.4
Apr 17 04:35	2269	RD	5.4	145	57	327	+2.0	-2.3
Apr 18 00:05	2404	RD	6.7	134	53	305	+0.9	-2.1
Apr 18 21:46	185573	RD	6.8	123	15	265	0.0	-0.9
Apr 20 04:13	2743	RD	7.6	108	78	330	+2.4	-6.3
Apr 22 00:47	189680	RD	7.4	83	13	266	+0.1	-0.9
Apr 23 03:38	3197	RD	6.4	68	33	179	+1.2	+5.2
May 04 19:18	1274	DD	5.7	80	27	118	+1.6	-0.1
May 04 20:20	1279	DD	6.4	81	21	70	+2.6	+2.1
May 06 19:57	1485	DD	7.1	103	40	147	+1.2	-1.4
May 07 18:47	1576	RB	5.3	113	44	314	+1.7	-1.7
May 12 00:12	1986	DD	7.1	160	59	97	+2.3	+0.4
May 13 02:29	2099	DD	6.9	172	45	133	+1.5	-0.8

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 14 19:38	2349	DB	2.9	165	24	94	+0.3	-1.2
May 14 20:36	2349	RD	2.9	165	35	311	+0.2	-2.0
May 15 00:14	Antares	DB	1.1	163	78	107	+2.1	-1.1
May 15 01:43	Antares	RD	1.1	163	77	287	+2.3	-0.5
May 15 02:59	2373	RD	6.1	163	63	283	+2.0	+0.2
Jun 03 19:56	99198	DD	7.3	83	35	102	+2.0	+0.4
Jun 05 18:44	1730	DD	6.2	105	56	199	-1.8	-5.0
Jun 06 23:21	1836	DD	6.3	118	33	159	+0.7	-1.9
Jun 10 20:42	2295	DD	7.2	163	62	112	+1.5	-1.5
Jun 11 03:56	2332	DD	6.1	166	25	59	0.0	+2.1
Jun 12 18:13	2583	RD	5.8	171	12	242	+0.3	-0.3
Jun 12 22:25	2617	DB	4.6	169	61	128	+1.2	-2.5
Jun 12 22:53	186286	RD	7.1	169	67	259	+2.1	-0.1
Jun 12 23:34	2617	RD	4.6	168	75	242	+2.4	+1.0
Jun 13 02:18	186461	RD	7.4	167	69	279	+2.1	+0.2
Jun 13 04:35	2644	RD	6.4	167	42	221	+0.1	+2.6
Jun 13 04:38	186598	RD	7.5	167	41	324	+2.8	-2.3
Jun 13 20:51	187672	RD	7.4	157	30	243	+0.9	-0.2
Jun 13 22:30	2796	RD	6.9	156	49	281	+1.2	-1.4
Jun 14 00:33	2805	RD	7.1	155	74	323	+2.3	-5.1
Jun 15 21:34	3090	RD	6.7	130	12	205	+0.8	+1.4
Jun 16 22:37	3240	RD	6.7	116	11	168	+9.9	+9.9
Jun 17 01:38	164931	RD	7.6	115	47	174	+0.4	+5.5
Jun 17 03:53	3268	DB	5.3	114	67	30	+1.2	+2.1
Jun 17 05:06	3268	RD	5.3	114	68	253	+2.1	+0.9
Jun 20 03:06	98	RD	6.0	74	23	273	+1.2	-1.4
Jun 30 18:23	1504	RB	5.4	53	29	332	+0.5	-1.2
Jul 01 20:03	118636	DD	7.3	65	23	124	+0.8	-0.1
Jul 01 21:00	1609	DD	4.6	65	13	125	+0.4	-0.1
Jul 03 22:05	1795	DD	6.9	87	22	89	+0.9	+1.4
Jul 04 17:51	1886	DD	5.6	97	65	158	+0.9	-2.7
Jul 04 19:11	1886	RB	5.6	97	62	287	+2.4	-0.4
Jul 06 17:58	2099	DD	6.9	120	63	135	+1.2	-2.2
Jul 06 22:54	2115	DD	7.2	121	46	66	+1.6	+2.7
Jul 07 21:08	2237	DD	5.0	133	77	82	+2.7	+0.7
Jul 07 22:27	2237	RB	5.0	133	63	319	+2.0	-1.8
Jul 07 22:48	183713	DD	7.4	133	60	161	+1.9	-3.8
Jul 08 00:06	2248	DD	7.6	134	44	151	+1.9	-2.2
Jul 08 16:48	Antares	DD	1.1	144	32	180	-1.9	-4.5
Jul 08 17:12	Antares	RB	1.1	144	37	224	+2.8	+1.6
Jul 09 00:49	2404	DD	6.7	146	47	35	+0.3	+4.4
Jul 09 20:04	185573	DD	6.8	157	60	58	+2.4	+0.8
Jul 10 05:18	2583	DD	5.8	161	8	119	+0.1	+0.3
Jul 12 20:04	3031	RD	5.9	161	20	320	-0.5	-4.0
Jul 12 22:33	3046	RD	7.1	160	50	289	+1.5	-2.0
Jul 12 23:25	3050	RD	7.4	160	60	278	+2.0	-1.2
Jul 13 06:18	3078	RD	4.9	157	27	228	+0.1	+1.8
Jul 13 20:34	3190	DB	2.9	147	12	48	+0.4	+0.3
Jul 13 21:30	3190	RD	2.9	147	24	273	+0.5	-1.2
Jul 14 02:11	3210	RD	7.2	145	71	240	+1.8	+1.1
Jul 14 05:59	3224	RD	7.6	144	39	198	0.0	+2.5
Jul 14 23:07	146296	RD	7.4	132	29	217	+0.8	+0.9
Jul 18 01:23	203	RD	6.8	91	15	243	+0.5	-0.2
Jul 20 04:07	470	RD	6.8	64	17	280	+1.7	-1.5
Jul 20 05:41	75832	RD	7.3	64	28	239	+1.4	+0.2
Jul 29 18:32	1668	DD	7.5	45	27	154	+0.5	-1.4
Aug 03 19:30	2183	DD	5.5	102	71	90	+2.6	+0.5
Aug 03 20:53	2183	RB	5.5	102	55	313	+1.8	-1.2
Aug 05 22:11	2474	DD	6.7	127	64	18	+0.4	+8.6
Aug 06 17:59	2617	RB	4.6	138	50	249	+1.7	-0.1
Aug 06 19:19	186461	DD	7.4	139	66	47	+2.6	+1.8
Aug 06 20:49	186536	DD	7.5	139	83	132	+2.3	-2.7
Aug 06 21:58	2644	DD	6.4	140	79	66	+2.0	+1.5
Aug 08 03:19	2852	DD	7.3	155	26	13	-0.9	+3.0
Aug 09 00:37	189348	DD	7.6	167	69	62	+1.6	+1.5
Aug 09 02:53	189425	DD	7.5	168	42	43	+0.3	+2.0
Aug 10 19:32	3268	RD	5.3	166	14	249	+0.3	-0.4
Aug 11 01:29	3295	RD	7.0	163	67	271	+2.6	+0.1
Aug 11 02:47	3307	DB	4.8	163	58	53	+1.3	+1.7
Aug 11 03:56	3307	RD	4.8	162	45	230	+0.9	+1.8

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 11 23:15	3430	RD	5.6	150	43	179	+0.1	+3.4
Aug 12 00:47	3437	RD	6.8	149	57	192	+0.6	+2.4
Aug 12 22:49	19	RD	7.5	136	25	235	+0.7	+0.2
Aug 13 04:13	109127	RD	7.2	134	47	262	+2.2	+0.9
Aug 13 22:48	145	RD	6.8	122	11	269	+0.6	-1.1
Aug 14 02:03	166	RD	6.7	121	41	217	+1.0	+1.1
Aug 16 02:59	438	RD	6.8	94	25	184	-0.5	+2.3
Aug 30 19:09	2134	DD	5.9	71	51	182	+1.6	-8.2
Aug 30 19:34	2134	RB	5.9	71	45	217	+1.2	+8.2
Aug 31 21:46	2273	DD	5.9	84	31	137	+1.3	-0.8
Sep 01 17:31	2405	DD	6.6	94	81	115	+2.2	-1.4
Sep 03 00:35	2583	DD	5.8	109	21	35	-0.7	+2.5
Sep 03 18:47	2727	DD	7.4	120	75	167	+9.9	+9.9
Sep 03 21:32	2743	DD	7.6	121	69	76	+1.8	+1.2
Sep 05 18:55	3050	DD	7.4	147	49	34	+1.5	+1.6
Sep 06 01:49	3078	DD	4.9	149	38	72	+0.7	+1.4
Sep 06 03:49	3084	DD	6.7	151	13	354	-1.3	+3.4
Sep 06 20:55	3210	DD	7.2	162	58	58	+1.6	+0.6
Sep 07 01:04	3224	DD	7.6	163	55	97	+2.2	+0.6
Sep 08 00:35	Uranus	DD	5.7	177	61	91	+2.6	+0.3
Sep 08 01:28	Uranus	RB	5.7	178	55	187	+0.1	+2.8
Sep 08 04:41	3383	RB	6.2	179	18	181	-0.3	+2.8
Sep 08 23:17	146911	RD	7.1	168	52	244	+1.7	+0.5
Sep 09 03:38	128449	RD	7.6	167	36	247	+1.2	+1.5
Sep 13 01:24	518	RD	6.0	112	20	213	+0.4	+0.8
Sep 14 03:21	696	RD	7.5	99	24	238	+1.5	+0.2
Sep 15 04:11	850	RD	6.0	86	22	207	+0.8	+1.4
Sep 16 04:30	1018	RD	5.8	74	19	245	+1.5	-0.2
Oct 02 20:28	189348	DD	7.6	115	75	38	+1.3	+2.4
Oct 02 23:02	189425	DD	7.5	116	45	17	-0.2	+2.9
Oct 04 22:15	3295	DD	7.0	143	65	46	+1.4	+1.7
Oct 05 00:40	3307	DD	4.8	144	41	86	+1.4	+1.2
Oct 05 01:33	3307	RB	4.8	144	31	202	+0.1	+2.3
Oct 07 00:08	109127	DD	7.2	172	50	44	+1.4	+1.6
Oct 07 21:53	166	RD	6.7	174	37	215	+0.8	+1.0
Oct 09 00:36	317	RD	6.4	159	39	196	+0.7	+1.8
Oct 13 02:10	948	RD	4.3	105	17	301	+2.2	-1.8
Oct 14 03:16	1103	RD	5.8	93	19	247	+1.6	-0.3
Oct 15 02:42	1233	RD	5.7	82	9	332	+1.9	-3.1
Oct 26 19:54	2474	DD	6.7	47	26	75	+0.2	+1.5
Oct 27 19:43	186434	DD	7.5	59	39	37	-0.1	+2.8
Oct 27 19:56	186461	DD	7.4	59	37	94	+0.9	+1.0
Oct 27 22:09	186598	DD	7.5	60	11	67	-0.4	+1.4
Oct 27 22:11	2643	DD	6.7	60	11	19	-1.3	+2.9
Oct 28 20:59	2805	DD	7.1	72	35	108	+1.2	+0.6
Oct 30 19:25	3078	RB	4.9	96	71	284	+3.0	-0.3
Oct 31 19:21	3224	DD	7.6	109	70	74	+2.2	+0.7
Nov 02 19:37	146911	DD	7.1	137	52	70	+1.9	+0.3
Nov 03 00:07	128449	DD	7.6	139	35	67	+1.2	+1.5
Nov 04 22:30	244	DD	6.7	166	42	25	+0.9	+1.6
Nov 06 21:29	518	RD	6.0	165	18	244	+0.9	-0.2
Nov 07 01:03	76081	RD	7.5	164	31	196	+1.2	+2.2
Nov 07 01:16	529	RD	6.1	164	30	276	+2.4	+0.2
Nov 08 23:55	77506	RD	7.4	138	17	274	+1.7	-1.0
Nov 11 02:24	1181	RD	7.0	113	23	260	+2.0	-0.6
Nov 15 03:39	118636	RD	7.3	68	23	248	+1.7	-0.6
Nov 15 04:06	1609	DB	4.6	68	28	190	-0.1	-4.3
Nov 23 20:05	2583	RB	5.8	29	11	239	-0.5	+1.5
Nov 28 22:46	3333	DD	6.4	93	22	21	0.0	+2.3
Dec 02 20:33	317	DD	6.4	146	38	120	+4.4	-2.5
Dec 04 21:44	616	DD	5.4	171	26	144	+5.9	-5.6
Dec 04 22:04	616	RD	5.4	171	28	172	-2.3	+5.6
Dec 06 00:23	788	RD	6.8	170	27	253	+2.2	+0.4
Dec 06 00:42	77089	RD	7.3	170	27	217	+2.2	+1.7
Dec 09 00:32	80089	RD	7.2	134	22	236	+1.8	+0.2
Dec 09 01:11	1251	RD	5.9	134	26	207	+3.6	+7.6
Dec 13 02:33	1668	RD	7.5	89	29	235	+3.0	+0.8
Dec 19 14:42	Antares	DB	1.1	18	37	58	+0.4	+2.4
Dec 19 15:39	Antares	RD	1.1	18	25	303	+0.9	0.0
Dec 23 20:22	3014	DD	7.3	35	12	8	-0.9	+2.6

LUNAR OCCULTATION TABLE

DARWIN (12° 23' S, 130° 44' E)

CST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 23 03:12	2017	RD	6.4	88	39	248	+2.9	+1.0
Jan 25 05:19	2269	DB	5.4	63	45	123	+1.0	-1.5
Feb 05 21:21	X 54005	RB	5.6	92	39	259	+2.3	+0.9
Feb 05 21:21	440	RB	4.7	92	39	259	+2.3	+0.9
Feb 06 14:54	Pleiades	DD	3.0	102	14	114	+1.6	-1.8
Feb 06 15:32	Pleiades	RB	3.0	103	22	187	-1.0	+2.9
Feb 07 21:30	731	DD	6.0	116	47	107	+3.2	-0.6
Feb 09 01:52	897	DD	6.4	129	14	80	+1.2	+0.8
Feb 09 20:26	1032	DD	5.4	139	41	38	+1.9	+2.7
Feb 11 20:11	1274	DD	5.7	161	25	114	+1.8	-1.4
Feb 11 21:10	1279	DD	6.4	161	36	96	+2.3	-0.7
Feb 22 01:04	2349	RD	2.9	85	6	360	-1.9	-4.0
Feb 22 05:04	Antares	DB	1.1	83	57	32	+9.9	+9.9
Feb 22 05:12	Antares	RB	1.1	83	59	20	+9.9	+9.9
Feb 23 02:39	2505	RD	5.3	72	14	263	+0.4	-0.2
Mar 04 21:24	399	DD	5.7	60	13	55	+1.0	+1.5
Mar 09 20:18	1119	DD	5.8	120	49	133	+3.1	-2.2
Mar 09 21:02	1122	DD	3.8	120	50	81	+3.8	+0.5
Mar 09 22:31	1122	RB	3.8	120	45	322	+1.5	-2.0
Mar 09 23:25	1132	DD	6.4	120	38	72	+3.3	+1.4
Mar 20 05:15	2183	RD	5.5	126	72	305	+2.7	-1.7
Mar 23 05:54	2631	RD	6.5	89	68	283	+2.8	-0.9
Mar 24 01:58	2784	RD	3.3	78	8	279	-0.1	-0.6
Apr 02 20:19	616	DD	5.4	53	19	52	+1.7	+1.9
Apr 12 03:52	1730	DD	6.2	158	23	73	+1.4	+1.7
Apr 14 03:27	Spica	DB	1.0	178	50	136	+1.7	-1.7
Apr 14 04:46	Spica	RD	1.0	178	31	289	+1.3	-0.4
Apr 14 22:02	2017	RD	6.4	170	42	317	+0.7	-2.0
Apr 15 03:57	2029	RD	4.9	168	53	310	+2.1	-1.6
Apr 17 04:18	2273	RD	5.9	144	68	256	+3.3	+1.2
Apr 23 03:12	3197	RD	6.4	68	12	263	+0.4	-0.2
May 04 19:23	1274	RB	5.7	81	51	316	+1.9	-1.8

CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 04 19:40	1279	RD	6.4	81	50	21	+9.9	+9.9
May 11 01:53	1886	DD	5.6	149	43	109	+1.8	-0.5
May 14 22:46	Antares	DB	1.1	163	45	77	+2.3	+0.2
May 14 23:48	Antares	RD	1.1	163	59	335	+0.6	-3.2
May 23 05:50	35	RD	6.2	57	40	165	-1.0	+5.4
Jun 06 21:48	1836	DD	6.3	118	71	120	+2.6	-1.4
Jun 10 01:55	2183	DD	5.5	153	45	87	+1.9	+0.6
Jun 12 22:14	2617	RD	4.6	168	41	292	+1.1	-1.2
Jun 13 03:58	2645	RD	6.2	166	54	248	+1.7	+1.3
Jun 17 00:34	3256	RD	6.1	115	21	225	+0.9	+1.2
Jun 17 04:51	3275	RD	6.0	113	81	206	+1.4	+2.6
Jun 18 00:54	3388	RD	5.5	102	13	233	+0.5	+0.8
Jun 18 06:05	3412	DB	4.2	100	83	61	+2.4	+1.3
Jul 01 20:14	1609	DD	4.6	65	41	77	+3.1	+1.6
Jul 01 20:59	1609	RB	4.6	65	31	5	-0.6	-4.0
Jul 08 16:24	Antares	RB	1.1	144	8	255	+0.4	+0.1
Jul 29 21:07	1678	DD	5.8	47	11	64	+0.8	+2.4
Aug 06 02:05	2505	DD	5.3	129	21	44	-0.3	+2.0
Aug 06 20:33	2645	DD	6.2	140	63	66	+3.0	+1.0
Aug 06 23:50	2660	DD	6.2	141	61	30	+1.1	+3.6
Aug 10 05:34	3171	DB	3.7	175	27	87	+0.9	+0.5
Aug 11 03:44	3310	RD	6.4	162	65	249	+2.1	+1.1
Aug 11 22:38	3430	RD	5.6	150	28	289	+1.4	-1.7
Aug 14 03:09	173	RD	6.5	120	60	277	+3.7	-0.7
Aug 16 02:22	X 54005	RD	5.6	94	25	234	+0.5	+0.8
Aug 16 02:22	440	RD	4.7	94	25	234	+0.5	+0.8
Aug 31 20:13	2268	DD	4.5	84	57	69	+2.6	+1.7
Aug 31 21:30	2268	RB	4.5	84	39	312	+2.2	-1.6
Sep 03 00:54	2586	DD	6.0	109	20	116	+1.2	-0.5
Sep 07 03:15	3237	DD	4.3	164	40	86	+1.5	+0.6
Sep 07 04:07	3237	RB	4.3	165	28	200	-0.1	+2.3
Sep 09 03:01	3520	RD	5.8	167	64	222	+1.5	+1.9

CST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Sep 10 00:55	98	RD	6.0	153	62	173	-0.6	+3.8
Sep 10 01:52	105	DB	4.4	153	69	13	+0.6	+2.7
Sep 10 02:27	103	RD	5.9	153	70	229	+1.9	+1.6
Sep 10 02:59	105	RD	4.4	152	68	258	+2.9	+0.7
Sep 15 03:04	850	RD	6.0	86	21	308	+2.7	-2.5
Sep 16 05:53	1032	DB	5.4	73	39	49	+1.9	+1.7
Sep 17 04:01	1149	RD	4.1	62	12	276	+0.9	-0.6
Oct 01 20:30	2848	RB	5.6	102	71	235	+2.2	+1.8
Oct 04 02:47	3171	DD	3.7	131	16	101	+0.6	+0.1
Oct 05 00:27	3310	DD	6.4	144	60	68	+1.9	+1.2
Oct 05 00:39	3307	DD	4.8	144	57	347	-1.4	+4.5
Oct 05 01:13	3307	RB	4.8	144	49	291	+3.3	-1.0
Oct 05 19:34	3430	DD	5.6	156	36	29	+0.8	+1.9
Oct 11 00:24	616	RD	5.4	131	28	271	+1.6	-0.5
Oct 11 05:09	638	DB	5.0	129	46	50	+2.7	+1.9
Oct 11 06:26	638	RD	5.0	129	35	292	+1.8	-0.5
Oct 27 21:46	2644	DD	6.4	60	18	69	+0.1	+1.0
Oct 31 21:51	3237	DD	4.3	111	67	64	+2.0	+1.4
Oct 31 23:03	3237	RB	4.3	111	49	214	+0.6	+2.1
Nov 01 23:08	3379	DD	6.2	125	59	86	+2.6	+0.5
Nov 02 00:10	3383	DD	6.2	125	44	48	+1.0	+1.7
Nov 02 23:43	3520	DD	5.8	139	60	103	+3.8	-0.6
Nov 03 23:49	103	DD	5.9	153	65	108	+4.7	-1.2
Nov 04 00:09	105	DD	4.4	153	61	68	+2.3	+1.1
Nov 04 01:23	105	RB	4.4	153	46	212	+1.2	+2.2
Nov 09 05:06	897	RD	6.4	136	43	226	+3.8	+2.9
Nov 15 03:26	1609	RD	4.6	67	15	282	+0.7	-1.0
Dec 06 03:25	810	DB	1.7	169	39	141	+1.3	-2.1
Dec 06 04:23	810	RD	1.7	169	29	231	+2.6	+2.2
Dec 09 00:10	1251	RD	5.9	134	23	284	+1.5	-1.0
Dec 13 05:12	1678	RD	5.8	87	60	314	+1.9	-2.2
Dec 31 21:48	569	DD	5.3	141	52	80	+2.9	+0.4

HOBART (42° 48' S, 147° 13' E)

EST	Object	PD	Mag	Elg°	Alt°	PA°	A	B
Jan 03 21:16	3237	DD	4.3	46	11	12	-0.4	+2.2
Jan 10 22:37	616	DD	5.4	135	17	29	+1.7	+1.8
Jan 27 03:17	2554	RD	4.5	39	15	262	0.0	-1.0
Feb 05 20:42	440	DD	4.7	92	17	134	+1.8	-0.2
Feb 05 20:42	X 54005	DD	5.6	92	17	134	+1.8	-0.3
Feb 05 21:15	440	RB	4.7	92	13	184	+1.4	+3.2
Feb 09 21:33	1032	DD	5.4	139	18	111	+2.0	-0.4
Feb 11 23:01	1279	DD	6.4	161	23	148	+1.4	-1.2
Feb 13 01:11	1393	DD	6.5	172	26	138	+1.1	-0.6
Feb 13 22:19	1479	RD	6.4	175	23	259	+2.0	-1.0
Feb 14 21:53	1576	RD	5.3	165	18	236	+1.8	-0.5
Feb 19 01:23	1971	RD	5.5	121	44	329	+0.5	-2.4
Feb 22 01:35	2349	DB	2.9	85	29	101	+0.3	-1.5
Feb 22 02:36	2349	RD	2.9	85	40	302	+0.4	-2.0
Feb 22 06:12	Antares	DB	1.1	83	73	125	+1.6	-1.7
Feb 22 07:31	Antares	RD	1.1	83	70	266	+2.0	+0.7
Mar 07 19:59	824	DD	6.2	96	16	115	+1.8	+0.2
Mar 09 22:14	1122	DD	3.8	120	16	124	+1.3	+0.1
Mar 09 23:31	1122	RB	3.8	120	8	278	+1.2	+1.0
Mar 21 01:30	2299	RD	6.2	116	50	338	0.0	-3.1
Mar 22 23:40	2583	RD	5.8	92	14	276	-0.2	-1.2
Mar 23 03:37	2617	DB	4.6	90	55	101	+1.2	-1.4
Mar 23 04:55	2617	RD	4.6	90	68	270	+1.8	-0.6
Apr 04 19:07	921	DD	6.0	77	14	102	+1.7	+0.6
Apr 13 01:52	1814	DD	6.7	168	40	101	+1.7	+0.7
Apr 14 23:47	2017	RD	6.4	170	60	284	+1.9	-1.0
Apr 16 20:08	2235	RD	6.3	148	15	273	-0.1	-1.3
Apr 17 00:35	2257	RD	6.7	146	61	340	+0.3	-3.3
Apr 17 04:35	2269	RD	5.4	145	58	291	+1.7	0.0
Apr 18 00:16	2404	RD	6.7	134	51	276	+1.2	-1.3
Apr 18 23:48	2545	RD	6.4	122	36	336	-0.6	-3.4
May 04 19:16	1274	DD	5.7	80	21	143	+1.0	-0.5

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
May 04 20:02	1279	DD	6.4	81	17	104	+1.5	+0.6
May 05 21:51	1393	DD	6.5	92	14	84	+1.5	+1.6
May 07 18:52	1576	RB	5.3	113	35	294	+1.8	-1.2
May 11 19:53	1971	DD	5.5	158	43	68	+2.4	-0.5
May 14 19:50	2349	DB	2.9	165	25	116	0.0	-1.7
May 14 20:50	2349	RD	2.9	165	36	286	+0.5	-1.6
May 15 00:24	Antares	DB	1.1	163	71	142	+1.2	-2.6
May 15 01:31	Antares	RD	1.1	163	73	251	+2.2	+1.2
May 15 02:43	2373	RD	6.1	163	65	250	+1.8	+1.7
May 31 18:19	1233	DD	5.7	50	13	61	+2.6	+2.4
Jun 04 21:25	1644	DD	4.1	95	29	64	+2.9	+3.9
Jun 04 21:59	1644	RB	4.1	95	24	12	-0.8	-4.2
Jun 10 21:26	2299	DD	6.2	164	64	51	+3.2	+1.9
Jun 11 03:38	2332	DD	6.1	166	33	84	+0.6	+1.5
Jun 11 06:18	2349	DD	2.9	167	7	88	-0.4	+1.1
Jun 17 03:34	3268	DB	5.3	114	56	51	+1.4	+0.9
Jun 17 04:50	3268	RD	5.3	114	60	238	+1.5	+1.1
Jun 20 03:09	98	RD	6.0	74	17	245	+0.6	-0.5
Jun 30 18:23	1504	RB	5.4	53	24	299	+1.1	+0.2
Jul 01 21:05	1609	DD	4.6	65	12	162	0.0	-1.3
Jul 04 18:22	1886	DD	5.6	97	56	200	-1.9	-5.9
Jul 04 18:51	1886	RB	5.6	97	56	240	+4.8	+3.5
Jul 07 21:02	2237	DD	5.0	133	71	117	+1.8	-1.1
Jul 07 22:25	2237	RB	5.0	133	63	284	+1.8	+0.1
Jul 09 00:20	2404	DD	6.7	146	55	71	+1.3	+1.8
Jul 10 05:15	2583	DD	5.8	161	16	138	+0.7	0.0
Jul 10 22:09	2723	DD	6.6	171	65	36	+2.0	+2.4
Jul 12 20:24	3031	RD	5.9	161	23	276	+0.2	-1.5
Jul 13 06:00	3078	RD	4.9	157	34	219	+0.1	+2.0
Jul 13 20:37	3190	DB	2.9	147	12	81	+0.1	-1.0
Jul 13 21:34	3190	RD	2.9	147	22	239	+0.5	-0.3
Jul 17 00:33	64	RD	6.5	105	13	281	+0.8	-2.0

EST	OBJECT	PD	Mag	Elg°	Alt°	PA°	A	B
Aug 03 19:25	2183	DD	5.5	102	68	125	+1.7	-1.2
Aug 03 20:48	2183	RB	5.5	102	56	279	+1.7	+0.6
Aug 05 20:36	2470	DD	6.1	126	75	66	+2.1	+1.3
Aug 05 21:33	2474	DD	6.7	127	70	66	+1.8	+1.7
Aug 06 21:44	2644	DD	6.4	140	75	96	+1.9	-0.1
Aug 10 19:31	3268	RD	5.3	166	12	215	+0.4	+0.5
Aug 11 02:29	3307	DB	4.8	163	55	64	+1.4	+1.2
Aug 11 03:36	3307	RD	4.8	162	47	221	+0.8	+1.9
Aug 14 01:50	166	RD	6.7	121	30	201	+0.4	+1.2
Aug 28 18:59	Spica	DD	1.0	49	32	40	+9.9	+9.9
Aug 28 19:14	Spica	RB	1.0	49	29	16	+9.9	+9.9
Aug 31 23:31	2286	DD	5.4	85	17	31	-1.1	+4.0
Sep 03 00:16	2583	DD	5.8	109	30	54	-0.1	+2.1
Sep 06 01:33	3078	DD	4.9	149	43	82	+1.0	+1.4
Sep 06 17:46	3190	RB	2.9	160	20	228	+0.5	0.0
Sep 08 00:26	Uranus	DD	5.7	178	54	110	+3.0	-0.9
Sep 08 01:02	Uranus	RB	5.7	178	52	172	-0.6	+3.4
Sep 13 01:16	518	RD	6.0	112	11	194	-0.3	+1.1
Sep 15 03:53	850	RD	6.0	86	11	180	-2.8	+5.0
Sep 27 21:26	2237	DD	5.0	54	16	49	-0.6	+2.8
Sep 28 19:19	Antares	MB	1.1	65	49	5	+1.2	+1.1
Sep 28 20:01	2373	DD	6.1	65	42	45	+0.3	+3.4
Oct 05 00:24	3307	DD	4.8	144	44	96	+1.7	+1.0
Oct 05 01:12	3307	RB	4.8	144	36	192	0.0	+2.4
Oct 05 02:52	3313	DD	6.5	145	18	2	-0.4	+2.5
Oct 09 00:19	317	RD	6.4	159	29	182	-0.1	+1.9
Nov 04 22:16	244	DD	6.7	166	32	36	+1.0	+0.9
Nov 07 01:05	529	RD	6.1	164	22	266	+1.9	+0.2
Nov 28 22:26	3333	DD	6.4	93	27	30	+0.2	+2.1
Dec 08 01:31	1119	RD	5.8	146	18	337	+1.6	-1.8
Dec 19 14:22	Antares	DB	1.1	18	44	84	+1.0	+1.5
Dec 19 15:31	Antares	RD	1.1	18	32	281	+0.6	+1.0

MOON

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
1	19 39 56	- 26 23 04	23 10 48	- 07 08 55	23 39 43	- 03 13 00	02 50 09	+ 20 01 47	05 21 36	+ 28 13 27	08 44 56	+ 22 17 51	10 47 30	+ 09 26 58
2	20 43 23	- 22 42 29	00 03 09	- 00 08 01	00 32 37	+ 03 59 23	03 47 18	+ 24 25 37	06 21 01	+ 28 32 12	09 33 22	+ 18 04 18	11 29 47	+ 03 56 20
3	21 42 48	- 17 34 19	00 54 09	+ 06 43 05	01 25 11	+ 10 49 40	04 45 47	+ 27 19 44	07 18 11	+ 27 18 10	10 18 43	+ 13 12 06	12 11 29	- 01 42 12
4	22 38 05	- 11 27 35	01 45 01	+ 13 03 08	02 18 24	+ 16 54 50	05 44 29	+ 28 37 53	08 12 02	+ 24 44 43	11 01 54	+ 07 53 39	12 53 43	- 07 19 33
5	23 30 03	- 04 50 26	02 36 44	+ 18 34 45	03 12 55	+ 21 56 13	06 41 58	+ 28 22 02	09 02 15	+ 21 07 43	11 43 56	+ 02 19 12	13 37 35	- 12 46 03
6	00 19 58	+ 01 52 53	03 29 58	+ 23 03 21	04 08 54	+ 25 39 35	07 36 58	+ 26 40 57	09 49 08	+ 16 42 21	12 25 56	- 03 22 03	14 24 15	- 17 49 53
7	01 09 07	+ 08 22 13	04 24 49	+ 26 17 05	05 05 53	+ 27 55 47	08 28 48	+ 23 47 36	10 33 27	+ 11 41 39	13 08 59	- 09 00 43	15 14 44	- 22 15 48
8	01 58 44	+ 14 20 21	05 20 49	+ 28 07 28	06 02 50	+ 28 41 26	09 17 23	+ 19 56 02	11 16 07	+ 06 16 38	13 54 12	- 14 25 39	16 09 41	- 25 44 41
9	02 49 46	+ 19 31 46	06 16 56	+ 28 30 52	06 58 33	+ 27 59 23	10 03 09	+ 15 19 35	11 58 08	+ 00 37 03	14 42 39	- 19 22 47	17 09 03	- 27 54 48
10	03 42 47	+ 23 42 01	07 11 56	+ 27 29 32	07 51 58	+ 25 57 50	10 46 47	+ 10 10 09	12 40 33	- 05 07 28	15 35 11	- 23 34 18	18 11 42	- 28 26 05
11	04 37 47	+ 26 38 14	08 04 43	+ 25 11 13	08 42 31	+ 22 48 22	11 29 10	+ 04 38 28	13 24 24	- 10 46 14	16 32 04	- 26 39 13	19 15 28	- 27 06 50
12	05 34 05	+ 28 10 54	08 54 42	+ 21 47 32	09 30 10	+ 18 43 56	12 11 14	- 01 05 15	14 10 42	- 16 06 20	17 32 44	- 28 16 27	20 17 59	- 23 58 49
13	06 30 26	+ 28 16 04	09 41 51	+ 17 31 44	10 15 17	+ 13 57 19	12 53 55	- 06 50 23	15 00 22	- 20 51 58	18 35 28	- 28 10 12	21 17 34	- 19 17 19
14	07 25 26	+ 26 56 41	10 26 32	+ 12 37 03	10 58 32	+ 08 40 27	13 38 13	- 12 25 12	15 53 58	- 24 44 22	19 38 00	- 26 15 44	22 13 40	- 13 26 14
15	08 17 58	+ 24 21 55	11 09 26	+ 07 15 43	11 40 43	+ 03 04 31	14 25 01	- 17 35 59	16 51 28	- 27 23 21	20 38 18	- 22 41 21	23 06 47	- 06 52 17
16	09 07 29	+ 20 44 45	11 51 23	+ 01 38 53	12 22 43	- 02 39 46	15 15 09	- 22 06 45	17 51 57	- 28 30 51	21 35 19	- 17 45 23	23 57 56	- 00 00 55
17	09 54 05	+ 16 19 14	12 33 18	- 04 03 05	13 05 27	- 08 21 27	16 09 02	- 25 39 31	18 53 37	- 27 55 49	22 29 04	- 11 50 46	00 48 21	+ 06 44 56
18	10 38 16	+ 11 18 39	13 16 11	- 09 39 52	13 49 54	- 13 48 48	17 06 32	- 27 55 47	19 54 27	- 25 37 48	23 20 20	- 05 20 42	01 39 17	+ 13 04 49
19	11 20 49	+ 05 54 39	14 01 05	- 15 00 16	14 36 59	- 18 48 29	18 06 39	- 28 39 44	20 52 53	- 21 46 54	00 10 16	+ 01 23 02	02 31 45	+ 18 39 57
20	12 02 41	+ 00 17 23	14 49 02	- 19 51 07	15 27 31	- 23 05 03	19 07 44	- 27 42 09	21 48 20	- 16 40 28	01 00 08	+ 08 00 13	03 26 27	+ 23 12 47
21	12 44 53	- 05 23 42	15 40 58	- 23 56 13	16 21 57	- 26 20 56	20 07 59	- 25 03 13	22 41 05	- 10 38 55	01 51 11	+ 14 11 18	04 23 23	+ 26 27 41
22	13 28 34	- 10 58 48	16 37 22	- 26 56 08	17 20 11	- 28 17 39	21 06 06	- 20 52 31	23 32 01	- 04 03 20	02 44 21	+ 19 36 44	05 21 49	+ 28 13 00
23	14 14 53	- 16 16 17	17 37 59	- 28 29 49	18 21 11	- 28 38 52	22 01 39	- 15 26 27	00 22 17	+ 02 45 22	03 40 09	+ 23 57 14	06 20 20	+ 28 23 48
24	15 05 00	- 21 01 12	18 41 29	- 28 18 57	19 23 16	- 27 14 45	22 54 59	- 09 05 24	01 13 08	+ 09 25 56	04 38 20	+ 26 55 37	07 17 18	+ 27 03 31
25	15 59 51	- 24 54 06	19 45 42	- 26 14 10	20 24 34	- 24 05 23	23 46 57	- 02 11 55	02 05 41	+ 15 36 31	05 37 49	+ 28 20 04	08 11 25	+ 24 23 01
26	16 59 41	- 27 31 30	20 48 30	- 22 19 35	21 23 45	- 19 21 36	00 38 42	+ 04 50 07	03 00 42	+ 20 54 46	06 36 52	+ 28 07 24	09 02 07	+ 20 37 36
27	18 03 40	- 28 29 30	21 48 28	- 16 52 46	22 20 23	- 13 22 41	01 31 21	+ 11 35 53	03 58 23	+ 24 59 32	07 33 44	+ 26 24 05	09 49 28	+ 16 03 36
28	19 09 41	- 27 31 09	22 45 21	- 10 20 24	23 14 51	- 06 33 21	02 25 51	+ 17 40 22	04 58 04	+ 27 33 55	08 27 16	+ 23 23 51	10 34 03	+ 10 56 05
29	20 14 58	- 24 34 01			00 08 02	+ 00 39 01	03 22 40	+ 22 39 58	05 58 14	+ 28 29 07	09 17 07	+ 19 23 39	11 16 42	+ 05 28 02
30	21 17 20	- 19 52 38			01 01 00	+ 07 46 27	04 21 36	+ 26 15 07	06 57 00	+ 27 46 45	10 03 36	+ 14 39 58	11 58 22	- 00 09 39
31	22 15 51	- 13 53 48			01 54 47	+ 14 22 06			07 52 49	+ 25 37 39			12 40 04	- 05 47 17

	AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	13 22 52	- 11 15 23	16 25 06	- 26 46 27	19 04 20	- 27 38 28	22 32 39	- 10 56 50	00 50 35	+ 07 30 47
2	14 07 51	- 16 23 31	17 22 56	- 28 26 33	20 03 59	- 24 55 51	23 24 43	- 04 13 03	01 43 31	+ 13 57 42
3	14 56 03	- 20 58 53	18 23 40	- 28 31 50	21 02 14	- 20 39 47	00 16 47	+ 02 50 42	02 39 24	+ 19 39 50
4	15 48 19	- 24 45 26	19 25 37	- 26 51 57	21 58 31	- 15 04 20	01 10 02	+ 09 49 34	03 38 39	+ 24 11 40
5	16 45 02	- 27 23 48	20 26 54	- 23 26 41	22 53 03	- 08 29 33	02 05 32	+ 16 16 17	04 40 41	+ 27 10 36
6	17 45 42	- 28 33 38	21 26 12	- 18 27 15	23 46 38	- 01 19 57	03 03 58	+ 21 42 45	05 43 49	+ 28 22 34
7	18 48 47	- 27 58 32	22 23 03	- 12 14 13	00 40 17	+ 05 56 59	04 05 10	+ 25 43 31	06 45 46	+ 27 46 35
8	19 52 04	- 25 32 07	23 17 50	- 05 14 08	01 35 05	+ 12 52 17	05 08 00	+ 28 00 45	07 44 28	+ 25 34 23
9	20 53 31	- 21 21 35	00 11 27	+ 02 03 55	02 31 55	+ 18 57 28	06 10 26	+ 28 28 36	08 38 51	+ 22 05 27
10	21 52 02	- 15 46 17	01 05 00	+ 09 10 57	03 31 03	+ 23 47 10	07 10 23	+ 27 14 11	09 28 53	+ 17 40 47
11	22 47 33	- 09 12 53	01 59 31	+ 15 39 59	04 32 00	+ 27 02 19	08 06 24	+ 24 33 51	10 15 13	+ 12 38 52
12	23 40 49	- 02 10 09	02 55 44	+ 21 07 26	05 33 23	+ 28 33 17	08 58 06	+ 20 47 18	10 58 53	+ 07 14 23
13	00 32 55	+ 04 54 20	03 53 47	+ 25 14 20	06 33 26	+ 28 21 21	09 45 52	+ 16 13 03	11 41 00	+ 01 38 47
14	01 25 03	+ 11 35 51	04 53 07	+ 27 47 52	07 30 34	+ 26 37 12	10 30 34	+ 11 06 27	12 22 40	- 03 58 30
15	02 18 15	+ 17 32 44	05 52 30	+ 28 42 59	08 23 55	+ 23 36 51	11 13 13	+ 05 39 43	13 05 00	- 09 28 33
16	03 13 15	+ 22 26 18	06 50 23	+ 28 02 55	09 13 26	+ 19 37 32	11 54 54	+ 00 02 59	13 49 05	- 14 41 34
17	04 10 09	+ 26 01 07	07 45 32	+ 25 57 51	09 59 38	+ 14 54 54	12 36 40	- 05 34 27	14 35 54	- 19 25 42
18	05 08 23	+ 28 06 15	08 37 17	+ 22 42 07	10 43 21	+ 09 42 20	13 19 32	- 11 02 49	15 26 14	- 23 26 11
19	06 06 43	+ 28 37 06	09 25 39	+ 18 31 05	11 25 30	+ 04 11 12	14 04 30	- 16 10 52	16 20 27	- 26 25 40
20	07 03 42	+ 27 36 30	10 11 06	+ 13 39 22	12 07 05	- 01 28 15	14 52 24	- 20 45 03	17 18 09	- 28 06 15
21	07 58 04	+ 25 14 03	10 54 22	+ 08 20 01	12 49 02	- 07 05 58	15 43 47	- 24 29 29	18 18 04	- 28 13 30
22	08 49 10	+ 21 43 42	11 36 19	+ 02 44 37	13 32 18	- 12 31 11	16 38 41	- 27 07 00	19 18 20	- 26 41 02
23	09 37 02	+ 17 20 52	12 17 52	- 02 56 04	14 17 44	- 17 31 49	17 36 26	- 28 21 49	20 17 07	- 23 32 59
24	10 22 05	+ 12 20 24	12 59 55	- 08 31 36	15 06 06	- 21 53 57	18 35 36	- 28 03 10	21 13 18	- 19 02 50
25	11 05 04	+ 06 55 37	13 43 24	- 13 51 07	15 57 49	- 25 22 11	19 34 28	- 26 08 33	22 06 40	- 13 29 25
26	11 46 52	+ 01 18 14	14 29 10	- 18 42 41	16 52 49	- 27 40 34	20 31 35	- 22 44 19	22 57 47	- 07 13 21
27	12 28 24	- 04 21 14	15 17 58	- 22 52 48	17 50 21	- 28 35 02	21 26 15	- 18 03 35	23 47 39	- 00 34 59
28	13 10 38	- 09 52 45	16 10 15	- 26 06 22	18 49 08	- 27 56 21	22 18 37	- 12 23 03	00 37 30	+ 06 05 54
29	13 54 33	- 15 05 55	17 06 00	- 28 07 27	19 47 36	- 25 42 33	23 09 22	- 06 00 56	01 28 37	+ 12 29 25
30	14 41 06	- 19 48 58	18 04 28	- 28 41 30	20 44 35	- 21 59 20	23 59 36	+ 00 43 47	02 22 07	+ 18 14 44
31	15 31 07	- 23 47 57			21 39 32	- 16 58 41			03 18 43	+ 22 59 59

MOON PHASES (UT)

Lunation	New Moon		First Quarter	
1027			Jan 6	18:56
1028	Jan 29	14:15	Feb 5	06:29
1029	Feb 28	00:31	Mar 6	20:16
1030	Mar 29	10:15	Apr 5	12:01
1031	Apr 27	19:44	May 5	05:13
1032	May 27	05:26	Jun 3	23:06
1033	Jun 25	16:05	Jul 3	16:37
1034	Jul 25	04:31	Aug 2	08:46
1035	Aug 23	19:10	Aug 31	22:57
1036	Sep 22	11:45	Sep 30	11:04
1037	Oct 22	05:14	Oct 29	21:25
1038	Nov 20	22:18	Nov 28	06:29
1039	Dec 20	14:01	Dec 27	14:48
	Full Moon		Last Quarter	
1027	Jan 14	09:48	Jan 22	15:14
1028	Feb 13	04:44	Feb 21	07:17
1029	Mar 14	23:35	Mar 22	19:11
1030	Apr 13	16:40	Apr 21	03:28
1031	May 13	06:51	May 20	09:21
1032	Jun 11	18:03	Jun 18	14:08
1033	Jul 11	03:02	Jul 17	19:13
1034	Aug 9	10:54	Aug 16	01:51
1035	Sep 7	18:42	Sep 14	11:15
1036	Oct 7	03:13	Oct 14	00:26
1037	Nov 5	12:58	Nov 12	17:45
1038	Dec 5	00:25	Dec 12	14:32
1039				

PERIGEE AND APOGEE OF THE MOON (UT)

PERIGEE						APOGEE					
Date	hr	km	Date	hr	km	Date	hr	km	Date	hr	km
Jan 1	23	361,750	Jul 13	18	364,288	Jan 17	19	405,885	Jul 29	13	405,406
Jan 30	8	357,778	Aug 10	18	359,749	Feb 14	1	406,359	Aug 26	1	406,269
Feb 27	20	356,884	Sep 8	3	357,175	Mar 13	2	406,278	Sep 22	5	406,500
Mar 28	7	359,168	Oct 6	14	357,410	Apr 9	13	405,551	Oct 19	10	406,074
Apr 25	11	363,732	Nov 4	0	360,596	May 7	7	404,572	Nov 15	23	405,194
May 22	15	368,608	Dec 2	0	365,923	Jun 4	2	404,081	Dec 13	19	404,418
Jun 16	17	368,919	Dec 28	2	370,323	Jul 1	20	404,448			

MERCURY

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	
Jan 7	04:14	18:48	04:05	18:01	04:01	18:37	05:37	18:28	03:43	19:09	04:09	19:01	04:23	18:41	03:56	18:25	Jan 7
14	04:35	19:07	04:26	18:21	04:21	18:56	05:57	18:48	04:04	19:28	04:30	19:21	04:44	19:01	04:17	18:44	14
21	05:01	19:24	04:51	18:38	04:47	19:13	06:20	19:08	04:32	19:43	04:57	19:36	05:09	19:18	04:42	19:01	21
28	05:31	19:37	05:19	18:54	05:18	19:25	06:44	19:27	05:06	19:53	05:28	19:48	05:39	19:31	05:12	19:14	28
Feb 4	06:05	19:46	05:49	19:06	05:52	19:34	07:09	19:45	05:44	19:57	06:03	19:56	06:11	19:42	05:46	19:23	Feb 4
11	06:40	19:51	06:20	19:15	06:27	19:39	07:34	20:00	06:24	19:57	06:40	19:59	06:45	19:48	06:20	19:29	11
18	07:11	19:49	06:48	19:18	06:59	19:38	07:54	20:10	07:01	19:50	07:13	19:56	07:14	19:49	06:51	19:28	18
25	07:28	19:37	07:01	19:09	07:16	19:25	08:02	20:07	07:22	19:34	07:32	19:42	07:29	19:38	07:08	19:16	25
Mar 4	07:15	19:09	06:46	18:42	07:03	18:57	07:43	19:43	07:11	19:03	07:20	19:13	07:15	19:10	06:54	18:48	Mar 4
11	06:27	18:28	06:00	18:00	06:15	18:16	06:58	18:59	06:23	18:23	06:32	18:32	06:28	18:28	06:07	18:07	11
18	05:28	17:48	05:03	17:18	05:16	17:36	06:06	18:13	05:21	17:47	05:32	17:54	05:30	17:48	05:08	17:27	18
25	04:45	17:21	04:22	16:49	04:33	17:09	05:28	17:41	04:35	17:22	04:47	17:28	04:47	17:20	04:25	17:00	25
Apr 1	04:24	17:05	04:01	16:33	04:11	16:53	05:08	17:24	04:13	17:07	04:26	17:12	04:27	17:04	04:04	16:44	Apr 1
8	04:20	16:56	03:57	16:25	04:08	16:45	05:03	17:17	04:10	16:57	04:23	17:03	04:23	16:56	04:00	16:35	8
15	04:29	16:52	04:03	16:22	04:16	16:40	05:07	17:17	04:21	16:50	04:32	16:57	04:31	16:52	04:08	16:31	15
22	04:46	16:49	04:18	16:22	04:34	16:37	05:17	17:22	04:42	16:45	04:51	16:54	04:48	16:51	04:26	16:29	22
29	05:12	16:50	04:41	16:26	05:00	16:37	05:34	17:31	05:11	16:41	05:17	16:53	05:12	16:52	04:50	16:30	29
May 6	05:45	16:54	05:10	16:33	05:33	16:41	05:57	17:45	05:49	16:40	05:52	16:55	05:43	16:58	05:23	16:34	May 6
13	06:26	17:03	05:47	16:47	06:15	16:51	06:28	18:06	06:36	16:44	06:36	17:03	06:23	17:09	06:04	16:44	13
20	07:15	17:21	06:32	17:08	07:03	17:08	07:05	18:34	07:31	16:56	07:26	17:18	07:10	17:28	06:52	17:02	20
27	08:03	17:45	07:17	17:36	07:52	17:32	07:45	19:07	08:23	17:16	08:16	17:41	07:57	17:55	07:40	17:27	27
Jun 3	08:41	18:13	07:53	18:06	08:30	18:00	08:19	19:38	09:03	17:42	08:54	18:09	08:34	18:23	08:17	17:56	Jun 3
10	09:03	18:39	08:16	18:31	08:52	18:26	08:43	20:02	09:25	18:09	09:16	18:35	08:56	18:48	08:40	18:21	10
17	09:10	18:58	08:25	18:48	08:59	18:45	08:54	20:16	09:29	18:30	09:22	18:54	09:04	19:06	08:47	18:40	17
24	09:03	19:05	08:19	18:53	08:51	18:52	08:52	20:18	09:19	18:41	09:14	19:03	08:57	19:13	08:40	18:47	24
Jul 1	08:42	18:59	08:01	18:45	08:31	18:46	08:37	20:07	08:55	18:37	08:52	18:57	08:37	19:05	08:19	18:40	Jul 1
8	08:08	18:35	07:28	18:20	07:57	18:22	08:07	19:39	08:19	18:15	08:18	18:34	08:04	18:41	07:46	18:16	8
15	07:24	17:54	06:45	17:39	07:13	17:42	07:24	18:57	07:35	17:35	07:34	17:54	07:20	18:00	07:02	17:36	15
22	06:40	17:07	06:00	16:51	06:29	16:54	06:39	18:11	06:51	16:47	06:50	17:06	06:35	17:12	06:18	16:48	22
29	06:08	16:27	05:27	16:13	05:57	16:15	06:04	17:34	06:21	16:06	06:18	16:26	06:03	16:34	05:46	16:09	29
Aug 5	05:56	16:08	05:14	15:55	05:45	15:55	05:49	17:18	06:10	15:45	06:07	16:06	05:51	16:15	05:33	15:50	Aug 5
12	06:02	16:14	05:20	16:00	05:50	16:01	05:54	17:24	06:16	15:50	06:13	16:11	05:57	16:21	05:39	15:55	12
19	06:18	16:41	05:37	16:26	06:06	16:28	06:14	17:48	06:31	16:19	06:28	16:39	06:14	16:48	05:55	16:22	19
26	06:34	17:20	05:56	17:02	06:22	17:07	06:38	18:19	06:43	17:02	06:43	17:20	06:31	17:25	06:12	17:00	26
Sep 2	06:44	17:59	06:10	17:38	06:33	17:47	06:58	18:48	06:48	17:47	06:52	18:01	06:43	18:03	06:23	17:40	Sep 2
9	06:49	18:35	06:19	18:09	06:37	18:22	07:13	19:13	06:48	18:27	06:54	18:38	06:49	18:37	06:28	18:14	9
16	06:49	19:05	06:23	18:36	06:37	18:53	07:24	19:33	06:43	19:03	06:53	19:10	06:51	19:06	06:29	18:45	16
23	06:47	19:32	06:25	18:59	06:35	19:20	07:32	19:50	06:36	19:35	06:50	19:39	06:50	19:31	06:28	19:11	23
30	06:44	19:56	06:25	19:20	06:31	19:44	07:38	20:04	06:29	20:03	06:45	20:04	06:49	19:54	06:25	19:34	30
Oct 7	06:40	20:16	06:24	19:37	06:27	20:05	07:42	20:16	06:20	20:27	06:39	20:26	06:46	20:13	06:21	19:54	Oct 7
14	06:35	20:32	06:21	19:49	06:22	20:20	07:45	20:24	06:11	20:47	06:33	20:43	06:42	20:27	06:16	20:09	14
21	06:27	20:38	06:15	19:54	06:14	20:27	07:42	20:25	06:00	20:55	06:24	20:50	06:34	20:32	06:08	20:15	21
28	06:11	20:25	06:00	19:40	05:58	20:14	07:28	20:11	05:44	20:43	06:08	20:37	06:19	20:18	05:53	20:02	28
Nov 4	05:40	19:38	05:28	18:56	05:27	19:27	06:52	19:29	05:15	19:54	05:37	19:50	05:47	19:32	05:22	19:16	Nov 4
11	04:55	18:24	04:39	17:46	04:43	18:13	05:57	18:25	04:36	18:35	04:54	18:34	05:01	18:20	04:36	18:02	11
18	04:20	17:34	04:02	16:58	04:08	17:23	05:16	17:41	04:04	17:42	04:20	17:43	04:25	17:31	04:01	17:13	18
25	04:04	17:26	03:46	16:48	03:51	17:15	05:02	17:31	03:47	17:35	04:04	17:35	04:09	17:23	03:45	17:04	25
Dec 2	04:00	17:40	03:44	17:00	03:47	17:29	05:04	17:39	03:39	17:52	03:59	17:50	04:06	17:36	03:41	17:18	Dec 2
9	04:02	18:03	03:49	17:20	03:49	17:52	05:13	17:55	03:38	18:18	04:00	18:14	04:09	17:58	03:44	17:40	9
16	04:09	18:28	03:59	17:43	03:56	18:17	05:26	18:14	03:42	18:47	04:06	18:40	04:18	18:22	03:51	18:05	16
23	04:21	18:53	04:13	18:06	04:08	18:42	05:43	18:34	03:52	19:14	04:17	19:06	04:30	18:46	04:03	18:30	23
30	04:39	19:16	04:31	18:29	04:25	19:05	06:02	18:56	04:07	19:39	04:34	19:30	04:48	19:09	04:21	18:53	30

The TRANSIT of MERCURY 9th NOVEMBER 2006

From the Earth's position in the Solar System, only the inner planets, Mercury and Venus, can ever pass across the face of the Sun. This event can only occur when the inner planet is at inferior conjunction (between the Earth and the Sun), and when the planetary orbits line up at just the right place and time.

Mercury transits the Sun on the 9th November 2006, the first time since 7th May 2003. Transits of Mercury occur on average thirteen or fourteen times each century (fourteen this current century), at intervals of about three, seven, ten or thirteen years (see table 1). The Venus transits are even less common than those of Mercury. They occur in pairs separated eight years apart at intervals of more than a century (see table 2). Since the invention of the telescope, only seven transits of Venus have been observed.

Transits of Mercury (or Venus) are only possible when the planet crosses the ecliptic, or the nodes of its orbit (the intersection points of a planet's orbit with the plane of the Earth's orbit) at inferior conjunction (Diagram 1). Because of Mercury's 7° orbital inclination to the plane of the ecliptic (Diagram 2), transits are not frequent, as the planet usually passes above or below the Sun, as seen from Earth. The innermost planet's large orbital tilt is only exceeded by Pluto, which has an inclination of 17°. During the present era, transits of Mercury always occur within a few days of 8th May and 10th November. November transits are more frequent than those in May and occur at intervals of 7, 13, or 33 years; May transits only occur at intervals of 13 or 33 years.

TABLE 1.
TRANSITS of MERCURY from 2001 to 2100

2003	7th	May
2006	8th	November
2016	9th	May
2019	11th	November
2032	13th	November
2039	7th	November
2049	7th	May
2052	9th	November
2062	10th	May
2065	11th	November
2078	14th	November
2085	7th	November
2095	8th	May
2098	10th	November

The progress of the transit may be monitored with a telescope using normal safe solar observing techniques and a magnification of between about 60 to 100x. The two most widely used and recommended methods for viewing are the projection method, or by use of a full aperture filter that reduces most of the light before it enters the telescope (do not forget to cover the objective of the finder scope, to prevent any nasty burns). **Warning! Do not risk blindness, the Sun is an intense radiator of infrared and ultraviolet radiation and can cause permanent eye damage.** We would strongly recommend that anyone wishing to see the transit, with no previous solar observing experience, observe the event with experienced amateurs familiar with this field. You could always try contacting a local astronomical society to see what events they are running.

TABLE 2.
TRANSITS of VENUS from 1801 to 2300

1874	9th	December
1882	6th	December
2004	8th	June
2012	6th	June
2117	11th	December
2125	8th	December
2247	11th	June
2255	9th	June

The early stages of the transit occur low to the horizon, and the atmosphere may not be steady. Poor seeing can be reduced by avoiding viewing over nearby buildings and large concrete areas. Minimise internal currents within the telescope by preventing direct sunlight from falling on the tube (a cardboard shield near the top end works fine), and give the telescope time to reach ambient temperature if it was stored indoors. If you are mobile, find a location looking over a large body of water or an expanse of grass. These areas tend to have steadier seeing.

What can an observer expect to see? The entire transit is visible from eastern Australia and New Zealand. Observers west of a line drawn roughly from Rockhampton to Melbourne will see the Sun rise with the transit already in progress (see diagram 5). Observers from eastern Australia will need a very good eastern horizon, as the Sun's altitude

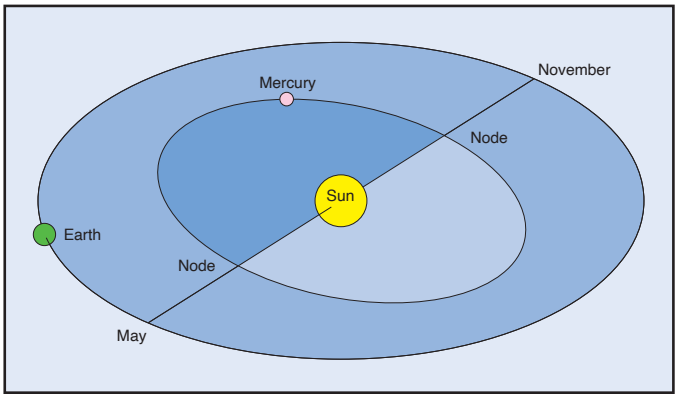


Diagram 1. A transit of Mercury is only possible if inferior conjunction occurs when the planet is at one of the nodes of its orbit. Mercury crosses the nodes of its orbit only in May and November.

CITY	Time zone	DURATION of TRANSIT	SUNRISE hm	TRANSIT BEGINS Contact 1 hms	Sun Alt. deg	INGRESS INTERIOR Contact 2 hms	Sun Alt. deg	LEAST ANGULAR DISTANCE hms	Sun Alt. deg	EGRESS INTERIOR Contact 3 hms	Sun Alt. deg	TRANSIT ENDS Contact 4 hms	Sun Alt. deg
Adelaide	CST	4h 37m 14.1s	05 : 07 am	- - -	- - -	- - -	- - -	07 : 11 : 20.1	24.1	09 : 38 : 37.5	53.8	19 : 40 : 30.0	54.2
Brisbane	EST	4h 58m 09.7s	04 : 52 am	05 : 12 : 12.8	3.7	05 : 14 : 05.5	4.1	07 : 41 : 20.7	36.1	10 : 08 : 29.9	68.0	10 : 10 : 22.4	68.4
Canberra	EST	4h 58m 17.8s	04 : 54 am	05 : 12 : 06.0	2.9	05 : 13 : 58.8	3.2	07 : 41 : 17.7	32.7	10 : 08 : 31.2	61.3	10 : 10 : 23.8	61.6
Darwin	CST	3h 31m 05.7s	06 : 12 am	- - -	- - -	- - -	- - -	07 : 11 : 32.5	13.2	09 : 38 : 46.3	48.2	19 : 40 : 38.9	48.7
Hobart	EST	4h 58m 23.5s	04 : 45 am	05 : 12 : 12.8	3.9	05 : 13 : 52.5	4.2	07 : 41 : 13.9	30.7	10 : 08 : 30.8	55.5	10 : 10 : 23.3	55.8
Melbourne	EST	4h 58m 22.6s	05 : 05 am	05 : 12 : 03.1	1.0	05 : 13 : 55.9	1.3	07 : 41 : 17.2	29.3	10 : 08 : 33.2	57.1	10 : 10 : 25.7	57.4
Perth	WST	3h 01m 30.9s	05 : 13 am	- - -	- - -	- - -	- - -	05 : 41 : 23.2	5.0	08 : 08 : 49.1	35.8	08 : 10 : 41.6	36.2
Sydney	EST	4h 58m 15.2s	04 : 48 am	05 : 12 : 07.5	4.1	05 : 14 : 00.2	4.5	07 : 41 : 17.9	34.5	10 : 08 : 30.2	63.5	10 : 10 : 22.7	63.8

TABLE 3. Local time of transit events from Australian capital cities. No account has been made for daylight saving and 1 hour should be added where applicable. Times given are based on the latitude and longitude of each location as provided on page 80.

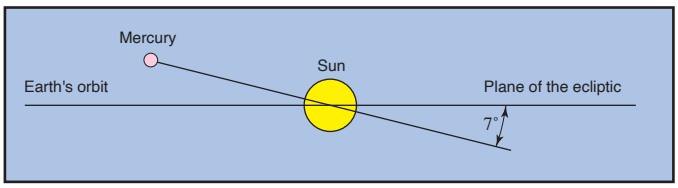


Diagram 2. Mercury's orbital tilt to the plane of the ecliptic. Transits are not very frequent as the planet generally passes above or below the Sun at inferior conjunction.

will be quite low at the commencement of the transit. Like an annular solar eclipse there are certain events, or contacts, that occur in the course of the transit as follows (see diagram 4). Local times of contact are shown in Table 3, and **no account has been made for daylight saving time (add 1 hour where applicable)**.

Contact 1:	Ingress, when the planet makes first exterior contact with the limb.
Contact 2:	Ingress, interior contact when the entire disc of the planet can first be seen.
Greatest transit:	When the planet is at its least angular distance from the Sun's centre
Contact 3:	Egress, interior contact when the entire disc is last visible.
Contact 4:	Egress, when the planet makes last exterior contact with the limb.

In reality contacts 1 and 4 are not visible in normal white light, but may be visible in Hydrogen-alpha light if the planet is silhouetted against either prominences or the chromosphere. For a short time before contact 2 the 'black drop effect' (diagram 3) might be seen, and looks like a trail or drop joining the planet to the Sun's limb. When the drop breaks, sunlight will be seen surrounding the planet and this is the true instant of contact 2; contact 3 occurs in precisely the opposite order.

Let's pray for clear skies, as this will be the last of the Mercury transits visible over Australia until 2032 and 2039. These two are favoured from Western Australia, from the eastern states the Sun sets prior to greatest transit. See also November section in part one for some interesting transit trivia.

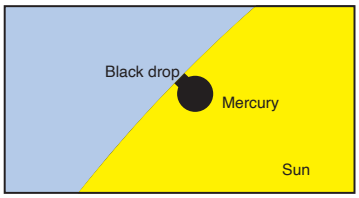


Diagram 3. The black drop effect.

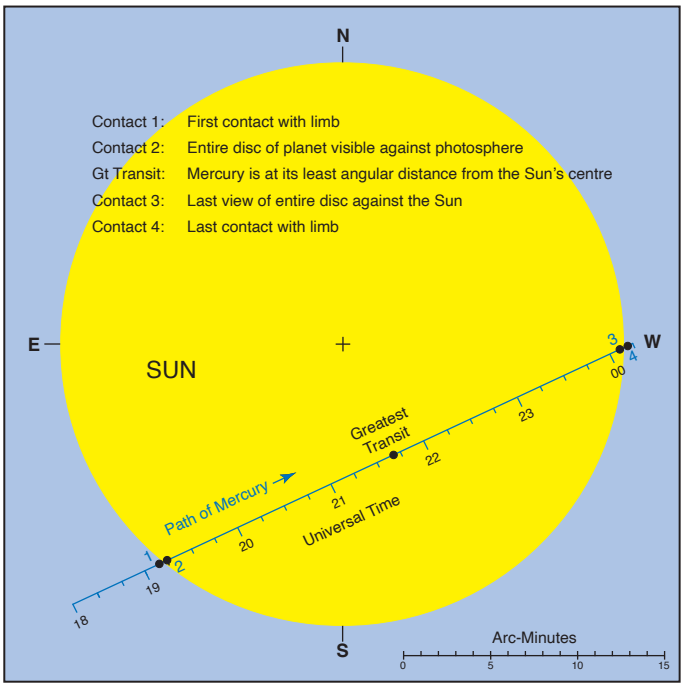


Diagram 4. Path and events of Mercury's transit of 8th November 2006.

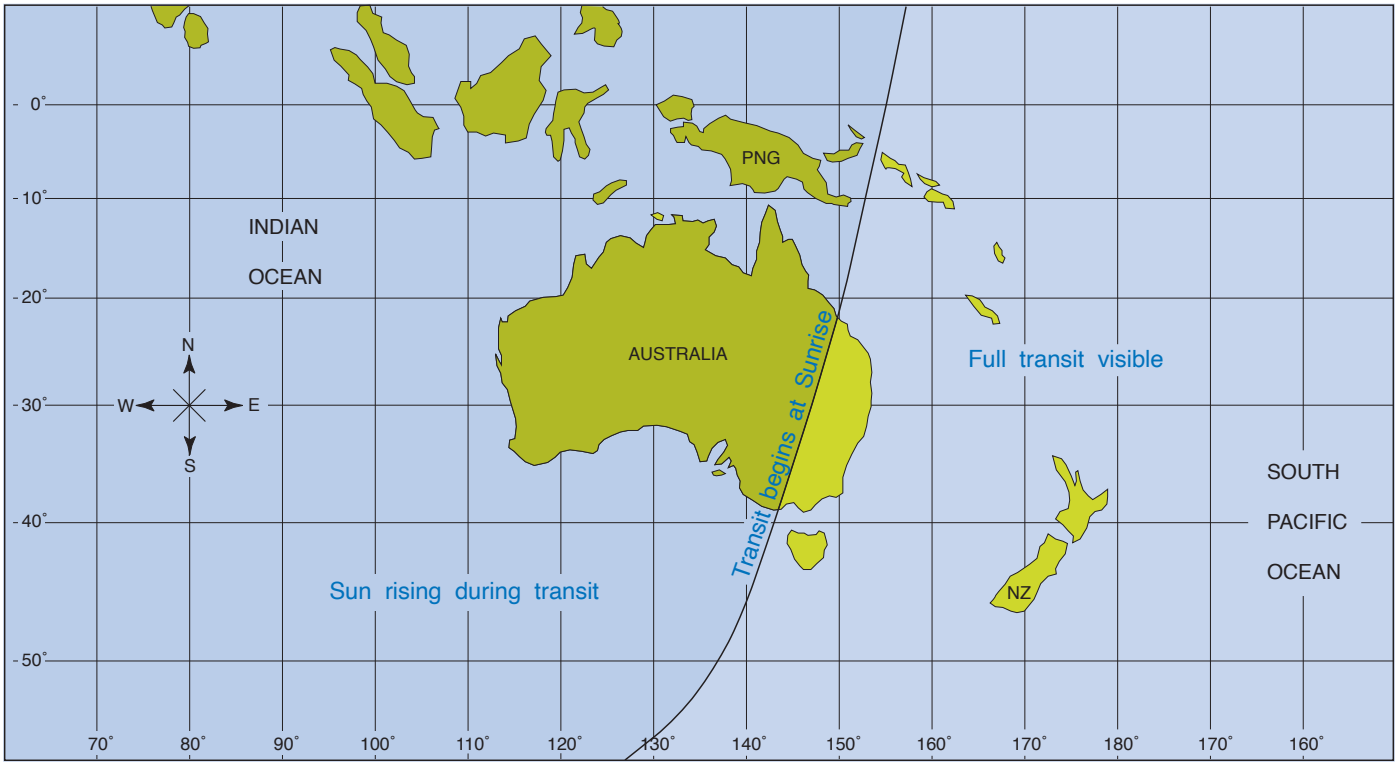


Diagram 5. For all locations east of the 'Transit begins at Sunrise' line the entire transit is visible. Observers west of this line will see the Sun rise with the transit already in progress.

MERCURY

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	17 40 43	- 23 31 39	21 14 33	- 18 06 49	23 43 23	+ 00 58 06	23 05 36	- 06 35 36	01 24 57	+ 06 27 07	05 39 19	+ 25 20 08
2	17 47 13	- 23 41 16	21 21 34	- 17 32 56	23 43 49	+ 01 15 08	23 08 02	- 06 32 47	01 31 24	+ 07 10 56	05 47 39	+ 25 26 40
3	17 53 46	- 23 49 45	21 28 33	- 16 57 35	23 43 43	+ 01 27 30	23 10 42	- 06 27 50	01 37 59	+ 07 55 25	05 55 50	+ 25 30 45
4	18 00 22	- 23 57 02	21 35 31	- 16 20 46	23 43 03	+ 01 35 04	23 13 35	- 06 20 50	01 44 41	+ 08 40 31	06 03 49	+ 25 32 31
5	18 07 00	- 24 03 08	21 42 27	- 15 42 33	23 41 52	+ 01 37 44	23 16 41	- 06 11 49	01 51 32	+ 09 26 08	06 11 36	+ 25 32 03
6	18 13 41	- 24 07 59	21 49 22	- 15 02 56	23 40 11	+ 01 35 31	23 19 58	- 06 00 53	01 58 30	+ 10 12 13	06 19 11	+ 25 29 29
7	18 20 24	- 24 11 35	21 56 14	- 14 22 00	23 38 03	+ 01 28 32	23 23 26	- 05 48 04	02 05 38	+ 10 58 41	06 26 34	+ 25 24 55
8	18 27 09	- 24 13 55	22 03 03	- 13 39 46	23 35 32	+ 01 16 58	23 27 04	- 05 33 28	02 12 54	+ 11 45 26	06 33 44	+ 25 18 28
9	18 33 56	- 24 14 57	22 09 49	- 12 56 20	23 32 40	+ 01 01 08	23 30 52	- 05 17 07	02 20 18	+ 12 32 22	06 40 41	+ 25 10 15
10	18 40 44	- 24 14 40	22 16 32	- 12 11 47	23 29 33	+ 00 41 25	23 34 49	- 04 59 05	02 27 53	+ 13 19 21	06 47 24	+ 25 00 24
11	18 47 35	- 24 13 03	22 23 10	- 11 26 12	23 26 15	+ 00 18 17	23 38 55	- 04 39 25	02 35 36	+ 14 06 18	06 53 54	+ 24 49 02
12	18 54 27	- 24 10 04	22 29 42	- 10 39 43	23 22 50	- 00 07 40	23 43 09	- 04 18 10	02 43 28	+ 14 53 02	07 00 09	+ 24 36 15
13	19 01 20	- 24 05 44	22 36 08	- 09 52 28	23 19 24	- 00 35 52	23 47 31	- 03 55 24	02 51 30	+ 15 39 25	07 06 11	+ 24 22 11
14	19 08 15	- 24 00 00	22 42 26	- 09 04 37	23 16 01	- 01 05 39	23 52 00	- 03 31 09	02 59 42	+ 16 25 18	07 11 58	+ 24 06 56
15	19 15 11	- 23 52 53	22 48 36	- 08 16 21	23 12 45	- 01 36 24	23 56 37	- 03 05 27	03 08 02	+ 17 10 28	07 17 31	+ 23 50 37
16	19 22 08	- 23 44 20	22 54 36	- 07 27 54	23 09 41	- 02 07 31	00 01 20	- 02 38 23	03 16 31	+ 17 54 46	07 22 49	+ 23 33 21
17	19 29 06	- 23 34 22	23 00 25	- 06 39 29	23 06 50	- 02 38 23	00 06 10	- 02 09 58	03 25 08	+ 18 37 59	07 27 52	+ 23 15 14
18	19 36 05	- 23 22 57	23 06 00	- 05 51 24	23 04 18	- 03 08 32	00 11 07	- 01 40 14	03 33 53	+ 19 19 55	07 32 41	+ 22 56 22
19	19 43 05	- 23 10 06	23 11 19	- 05 03 56	23 02 04	- 03 37 30	00 16 10	- 01 09 15	03 42 44	+ 20 00 22	07 37 14	+ 22 36 53
20	19 50 06	- 22 55 46	23 16 22	- 04 17 25	23 00 12	- 04 04 54	00 21 19	- 00 37 02	03 51 42	+ 20 39 06	07 41 31	+ 22 16 51
21	19 57 07	- 22 39 58	23 21 06	- 03 32 12	22 58 41	- 04 30 26	00 26 35	- 00 03 38	04 00 44	+ 21 15 58	07 45 33	+ 21 56 24
22	20 04 09	- 22 22 41	23 25 28	- 02 48 38	22 57 33	- 04 53 53	00 31 56	+ 00 30 55	04 09 50	+ 21 50 45	07 49 19	+ 21 35 38
23	20 11 11	- 22 03 54	23 29 27	- 02 07 07	22 56 48	- 05 15 03	00 37 24	+ 01 06 35	04 18 59	+ 22 23 17	07 52 48	+ 21 14 38
24	20 18 14	- 21 43 37	23 33 01	- 01 28 01	22 56 26	- 05 33 50	00 42 58	+ 01 43 19	04 28 08	+ 22 53 26	07 56 01	+ 20 53 32
25	20 25 16	- 21 21 49	23 36 07	- 00 51 43	22 56 25	- 05 50 10	00 48 39	+ 02 21 05	04 37 17	+ 23 21 05	07 58 57	+ 20 32 24
26	20 32 19	- 20 58 31	23 38 43	- 00 18 37	22 56 47	- 06 03 59	00 54 25	+ 02 59 51	04 46 24	+ 23 46 08	08 01 36	+ 20 11 23
27	20 39 22	- 20 33 41	23 40 49	+ 00 10 57	22 57 28	- 06 15 18	01 00 18	+ 03 39 34	04 55 29	+ 24 08 31	08 03 58	+ 19 50 33
28	20 46 25	- 20 07 21	23 42 22	+ 00 36 37	22 58 30	- 06 24 09	01 06 18	+ 04 20 12	05 04 28	+ 24 28 12	08 06 01	+ 19 30 01
29	20 53 28	- 19 39 29			22 59 51	- 06 30 32	01 12 24	+ 05 01 42	05 13 22	+ 24 45 11	08 07 47	+ 19 09 54
30	21 00 30	- 19 10 06			23 01 29	- 06 34 33	01 18 37	+ 05 44 01	05 22 09	+ 24 59 28	08 09 13	+ 18 50 17
31	21 07 32	- 18 39 13			23 03 24	- 06 36 12			05 30 49	+ 25 11 06		

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	08 10 22	+ 18 31 18	07 30 34	+ 18 38 11	10 41 50	+ 10 07 03	13 43 02	- 12 03 02	15 25 00	- 21 08 00	15 11 14	- 15 46 39
2	08 11 11	+ 18 13 02	07 32 13	+ 18 49 54	10 49 03	+ 09 21 30	13 48 14	- 12 39 51	15 22 55	- 20 47 55	15 16 28	- 16 13 39
3	08 11 41	+ 17 55 37	07 34 20	+ 19 00 55	10 56 09	+ 08 35 24	13 53 23	- 13 15 52	15 20 13	- 20 23 40	15 21 51	- 16 40 52
4	08 11 52	+ 17 39 07	07 36 54	+ 19 11 02	11 03 09	+ 07 48 52	13 58 30	- 13 51 06	15 16 55	- 19 55 17	15 27 21	- 17 08 09
5	08 11 44	+ 17 23 40	07 39 54	+ 19 20 06	11 10 03	+ 07 01 59	14 03 34	- 14 25 29	15 13 06	- 19 22 55	15 32 59	- 17 35 19
6	08 11 17	+ 17 09 21	07 43 22	+ 19 27 55	11 16 50	+ 06 14 53	14 08 35	- 14 59 00	15 08 49	- 18 46 55	15 38 43	- 18 02 16
7	08 10 32	+ 16 56 16	07 47 15	+ 19 34 17	11 23 32	+ 05 27 37	14 13 33	- 15 31 36	15 04 12	- 18 07 54	15 44 33	- 18 28 52
8	08 09 28	+ 16 44 30	07 51 34	+ 19 39 03	11 30 08	+ 04 40 17	14 18 27	- 16 03 17	14 59 22	- 17 26 39	15 50 27	- 18 55 02
9	08 08 07	+ 16 34 08	07 56 18	+ 19 42 01	11 36 38	+ 03 52 56	14 23 18	- 16 33 59	14 54 28	- 16 44 11	15 56 27	- 19 20 39
10	08 06 29	+ 16 25 13	08 01 25	+ 19 43 01	11 43 03	+ 03 05 39	14 28 04	- 17 03 41	14 49 40	- 16 01 41	16 02 31	- 19 45 40
11	08 04 36	+ 16 17 50	08 06 56	+ 19 41 53	11 49 23	+ 02 18 28	14 32 47	- 17 32 19	14 45 07	- 15 20 22	16 08 39	- 20 09 59
12	08 02 28	+ 16 12 01	08 12 48	+ 19 38 28	11 55 38	+ 01 31 28	14 37 24	- 17 59 52	14 40 57	- 14 41 29	16 14 51	- 20 33 33
13	08 00 09	+ 16 07 49	08 19 00	+ 19 32 37	12 01 48	+ 00 44 40	14 41 56	- 18 26 15	14 37 19	- 14 06 05	16 21 07	- 20 56 19
14	07 57 39	+ 16 05 13	08 25 31	+ 19 24 14	12 07 54	- 00 01 53	14 46 22	- 18 51 26	14 34 18	- 13 35 04	16 27 26	- 21 18 13
15	07 55 02	+ 16 04 13	08 32 19	+ 19 13 12	12 13 56	- 00 48 07	14 50 41	- 19 15 21	14 31 57	- 13 09 05	16 33 48	- 21 39 13
16	07 52 18	+ 16 04 49	08 39 22	+ 18 59 28	12 19 53	- 01 34 02	14 54 52	- 19 37 57	14 30 19	- 12 48 31	16 40 13	- 21 59 15
17	07 49 31	+ 16 06 59	08 46 38	+ 18 42 59	12 25 47	- 02 19 34	14 58 55	- 19 59 09	14 29 24	- 12 33 32	16 46 41	- 22 18 18
18	07 46 44	+ 16 10 38	08 54 05	+ 18 23 47	12 31 37	- 03 04 43	15 02 49	- 20 18 52	14 29 12	- 12 24 02	16 53 12	- 22 36 20
19	07 43 59	+ 16 15 43	09 01 41	+ 18 01 52	12 37 24	- 03 49 26	15 06 32	- 20 37 02	14 29 41	- 12 19 48	16 59 45	- 22 53 18
20	07 41 20	+ 16 22 08	09 09 25	+ 17 37 19	12 43 07	- 04 33 41	15 10 02	- 20 53 31	14 30 47	- 12 20 30	17 06 21	- 23 09 10
21	07 38 48	+ 16 29 48	09 17 13	+ 17 10 12	12 48 48	- 05 17 27	15 13 19	- 21 08 15	14 32 29	- 12 25 41	17 13 00	- 23 23 54
22	07 36 28	+ 16 38 36	09 25 05	+ 16 40 40	12 54 25	- 06 00 43	15 16 21	- 21 21 05	14 34 43	- 12 34 54	17 19 41	- 23 37 30
23	07 34 20	+ 16 48 23	09 32 58	+ 16 08 50	12 59 59	- 06 43 26	15 19 06	- 21 31 54	14 37 26	- 12 47 39	17 26 24	- 23 49 55
24	07 32 29	+ 16 59 04	09 40 51	+ 15 34 53	13 05 31	- 07 25 36	15 21 32	- 21 40 32	14 40 35	- 13 03 29	17 33 09	- 24 01 07
25	07 30 55	+ 17 10 28	09 48 43	+ 14 58 58	13 11 00	- 08 07 10	15 23 37	- 21 46 50	14 44 06	- 13 21 56	17 39 56	- 24 11 06
26	07 29 41	+ 17 22 28	09 56 32	+ 14 21 15	13 16 27	- 08 48 08	15 25 18	- 21 50 37	14 47 59	- 13 42 35	17 46 45	- 24 19 49
27	07 28 49	+ 17 34 54	10 04 18	+ 13 41 56	13 21 51	- 09 28 29	15 26 33	- 21 51 40	14 52 09	- 14 05 03	17 53 36	- 24 27 16
28	07 28 19	+ 17 47 37	10 11 59	+ 13 01 10	13 27 12	- 10 08 10	15 27 20	- 21 49 46	14 56 36	- 14 29 00	18 00 29	- 24 33 26
29	07 28 14	+ 18 00 29	10 19 36	+ 12 19 09	13 32 31	- 10 47 10	15 27 37	- 21 44 41	15 01 17	- 14 54 05	18 07 23	- 24 38 16
30	07 28 35	+ 18 13 18	10 27 07	+ 11 36 01	13 37 48	- 11 25 28	15 27 20	- 21 36 12	15 06 10	- 15 20 03	18 14 19	- 24 41 46
31	07 29 21	+ 18 25 55	10 34 31	+ 10 51 56			15 26 28	- 21 24 02			18 21 17	- 24 43 54

VENUS

GEOCENTRIC POSITION

(0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A.	Dec.	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec	R.A.	Dec
	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "	hh mm ss	° ' "
1	20 07 29	- 17 50 08	19 06 10	- 15 24 38	19 50 51	- 16 17 52	21 46 22	- 12 17 07	23 51 36	- 02 15 48	02 05 12	+ 10 31 55
2	20 05 53	- 17 39 07	19 05 52	- 15 26 28	19 53 57	- 16 16 41	21 50 28	- 12 02 07	23 55 49	- 01 51 46	02 09 41	+ 10 55 39
3	20 04 09	- 17 28 26	19 05 44	- 15 28 33	19 57 06	- 16 15 08	21 54 35	- 11 46 41	00 00 02	- 01 27 35	02 14 10	+ 11 19 10
4	20 02 16	- 17 18 05	19 05 46	- 15 30 50	20 00 19	- 16 13 10	21 58 42	- 11 30 51	00 04 15	- 01 03 15	02 18 40	+ 11 42 30
5	20 00 14	- 17 08 06	19 05 58	- 15 33 19	20 03 35	- 16 10 49	22 02 50	- 11 14 37	00 08 29	- 00 38 47	02 23 11	+ 12 05 37
6	19 58 05	- 16 58 29	19 06 20	- 15 35 57	20 06 55	- 16 08 03	22 06 58	- 10 57 59	00 12 43	- 00 14 13	02 27 43	+ 12 28 31
7	19 55 49	- 16 49 16	19 06 52	- 15 38 42	20 10 19	- 16 04 52	22 11 07	- 10 40 57	00 16 57	+ 00 10 28	02 32 16	+ 12 51 10
8	19 53 26	- 16 40 26	19 07 33	- 15 41 33	20 13 45	- 16 01 15	22 15 15	- 10 23 32	00 21 11	+ 00 35 15	02 36 50	+ 13 13 34
9	19 50 58	- 16 32 02	19 08 23	- 15 44 29	20 17 14	- 15 57 13	22 19 25	- 10 05 45	00 25 25	+ 01 00 08	02 41 25	+ 13 35 44
10	19 48 26	- 16 24 04	19 09 23	- 15 47 27	20 20 46	- 15 52 44	22 23 34	- 09 47 35	00 29 40	+ 01 25 05	02 46 01	+ 13 57 36
11	19 45 51	- 16 16 32	19 10 30	- 15 50 25	20 24 21	- 15 47 48	22 27 44	- 09 29 03	00 33 55	+ 01 50 06	02 50 38	+ 14 19 13
12	19 43 13	- 16 09 27	19 11 47	- 15 53 23	20 27 58	- 15 42 25	22 31 54	- 09 10 10	00 38 11	+ 02 15 11	02 55 16	+ 14 40 31
13	19 40 33	- 16 02 49	19 13 12	- 15 56 18	20 31 37	- 15 36 34	22 36 04	- 08 50 57	00 42 27	+ 02 40 18	02 59 55	+ 15 01 32
14	19 37 54	- 15 56 40	19 14 44	- 15 59 09	20 35 19	- 15 30 16	22 40 15	- 08 31 23	00 46 43	+ 03 05 28	03 04 35	+ 15 22 13
15	19 35 15	- 15 50 59	19 16 24	- 16 01 53	20 39 03	- 15 23 30	22 44 25	- 08 11 29	00 51 00	+ 03 30 39	03 09 17	+ 15 42 35
16	19 32 38	- 15 45 48	19 18 12	- 16 04 31	20 42 49	- 15 16 16	22 48 36	- 07 51 15	00 55 17	+ 03 55 51	03 13 59	+ 16 02 37
17	19 30 04	- 15 41 05	19 20 07	- 16 07 00	20 46 37	- 15 08 33	22 52 47	- 07 30 43	00 59 35	+ 04 21 03	03 18 42	+ 16 22 17
18	19 27 34	- 15 36 51	19 22 09	- 16 09 19	20 50 27	- 15 00 23	22 56 58	- 07 09 53	01 03 53	+ 04 46 15	03 23 27	+ 16 41 36
19	19 25 09	- 15 33 07	19 24 17	- 16 11 26	20 54 18	- 14 51 44	23 01 10	- 06 48 45	01 08 12	+ 05 11 26	03 28 13	+ 17 00 33
20	19 22 50	- 15 29 51	19 26 32	- 16 13 20	20 58 11	- 14 42 37	23 05 21	- 06 27 20	01 12 31	+ 05 36 35	03 33 00	+ 17 19 06
21	19 20 37	- 15 27 05	19 28 53	- 16 15 01	21 02 06	- 14 33 01	23 09 33	- 06 05 38	01 16 51	+ 06 01 42	03 37 48	+ 17 37 16
22	19 18 32	- 15 24 47	19 31 19	- 16 16 26	21 06 02	- 14 22 58	23 13 45	- 05 43 41	01 21 11	+ 06 26 45	03 42 37	+ 17 55 01
23	19 16 35	- 15 22 56	19 33 52	- 16 17 35	21 10 00	- 14 12 26	23 17 56	- 05 21 28	01 25 32	+ 06 51 45	03 47 27	+ 18 12 22
24	19 14 46	- 15 21 33	19 36 29	- 16 18 26	21 13 58	- 14 01 26	23 22 08	- 04 59 00	01 29 54	+ 07 16 40	03 52 19	+ 18 29 16
25	19 13 07	- 15 20 36	19 39 12	- 16 18 59	21 17 58	- 13 49 58	23 26 21	- 04 36 18	01 34 16	+ 07 41 30	03 57 11	+ 18 45 44
26	19 11 37	- 15 20 04	19 42 00	- 16 19 13	21 21 59	- 13 38 03	23 30 33	- 04 13 23	01 38 39	+ 08 06 14	04 02 05	+ 19 01 44
27	19 10 17	- 15 19 56	19 44 53	- 16 19 07	21 26 01	- 13 25 40	23 34 45	- 03 50 15	01 43 03	+ 08 30 52	04 07 00	+ 19 17 17
28	19 09 07	- 15 20 12	19 47 50	- 16 18 40	21 30 03	- 13 12 51	23 38 58	- 03 26 55	01 47 27	+ 08 55 22	04 11 56	+ 19 32 22
29	19 08 07	- 15 20 49			21 34 07	- 12 59 34	23 43 10	- 03 03 23	01 51 52	+ 09 19 44	04 16 53	+ 19 46 57
30	19 07 18	- 15 21 47			21 38 11	- 12 45 51	23 47 23	- 02 39 41	01 56 18	+ 09 43 57	04 21 51	+ 20 01 03
31	19 06 39	- 15 23 03			21 42 16	- 12 31 42			02 00 45	+ 10 08 01		

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	04 26 50	+ 20 14 38	07 07 11	+ 22 24 40	09 44 26	+ 14 42 44	12 04 37	+ 01 03 32	14 29 11	- 13 50 09	17 03 40	- 23 06 46
2	04 31 50	+ 20 27 43	07 12 25	+ 22 18 40	09 49 16	+ 14 19 40	12 09 11	+ 00 33 33	14 34 02	- 14 15 37	17 09 05	- 23 16 05
3	04 36 51	+ 20 40 16	07 17 39	+ 22 12 01	09 54 06	+ 13 56 12	12 13 45	+ 00 03 31	14 38 56	- 14 40 43	17 14 31	- 23 24 43
4	04 41 53	+ 20 52 17	07 22 52	+ 22 04 43	09 58 55	+ 13 32 21	12 18 19	- 00 26 33	14 43 50	- 15 05 27	17 19 58	- 23 32 37
5	04 46 56	+ 21 03 46	07 28 05	+ 21 56 47	10 03 43	+ 13 08 07	12 22 53	- 00 56 38	14 48 45	- 15 29 48	17 25 25	- 23 39 49
6	04 52 00	+ 21 14 42	07 33 18	+ 21 48 13	10 08 30	+ 12 43 31	12 27 28	- 01 26 43	14 53 41	- 15 53 45	17 30 53	- 23 46 18
7	04 57 05	+ 21 25 04	07 38 30	+ 21 39 00	10 13 16	+ 12 18 34	12 32 02	- 01 56 47	14 58 39	- 16 17 18	17 36 22	- 23 52 04
8	05 02 11	+ 21 34 53	07 43 41	+ 21 29 11	10 18 01	+ 11 53 16	12 36 37	- 02 26 51	15 03 38	- 16 40 26	17 41 51	- 23 57 05
9	05 07 17	+ 21 44 07	07 48 52	+ 21 18 43	10 22 45	+ 11 27 38	12 41 12	- 02 56 53	15 08 38	- 17 03 07	17 47 20	- 24 01 22
10	05 12 25	+ 21 52 46	07 54 02	+ 21 07 39	10 27 29	+ 11 01 41	12 45 47	- 03 26 52	15 13 39	- 17 25 22	17 52 50	- 24 04 55
11	05 17 33	+ 22 00 49	07 59 12	+ 20 55 58	10 32 12	+ 10 35 26	12 50 22	- 03 56 49	15 18 42	- 17 47 08	17 58 19	- 24 07 44
12	05 22 42	+ 22 08 17	08 04 21	+ 20 43 40	10 36 54	+ 10 08 52	12 54 58	- 04 26 41	15 23 46	- 18 08 27	18 03 50	- 24 09 48
13	05 27 51	+ 22 15 09	08 09 29	+ 20 30 47	10 41 36	+ 09 42 01	12 59 34	- 04 56 28	15 28 51	- 18 29 16	18 09 20	- 24 11 07
14	05 33 02	+ 22 21 24	08 14 37	+ 20 17 17	10 46 16	+ 09 14 54	13 04 11	- 05 26 10	15 33 57	- 18 49 35	18 14 50	- 24 11 41
15	05 38 13	+ 22 27 02	08 19 44	+ 20 03 13	10 50 57	+ 08 47 31	13 08 48	- 05 55 46	15 39 04	- 19 09 24	18 20 20	- 24 11 30
16	05 43 24	+ 22 32 02	08 24 50	+ 19 48 34	10 55 36	+ 08 19 53	13 13 26	- 06 25 14	15 44 13	- 19 28 40	18 25 51	- 24 10 35
17	05 48 37	+ 22 36 25	08 29 55	+ 19 33 21	11 00 15	+ 07 52 00	13 18 04	- 06 54 35	15 49 23	- 19 47 25	18 31 21	- 24 08 54
18	05 53 49	+ 22 40 11	08 35 00	+ 19 17 34	11 04 54	+ 07 23 54	13 22 43	- 07 23 47	15 54 34	- 20 05 36	18 36 51	- 24 06 28
19	05 59 02	+ 22 43 18	08 40 03	+ 19 01 13	11 09 31	+ 06 55 35	13 27 23	- 07 52 50	15 59 47	- 20 23 14	18 42 21	- 24 03 18
20	06 04 16	+ 22 45 46	08 45 06	+ 18 44 20	11 14 09	+ 06 27 04	13 32 03	- 08 21 43	16 05 00	- 20 40 17	18 47 50	- 23 59 23
21	06 09 30	+ 22 47 36	08 50 08	+ 18 26 55	11 18 46	+ 05 58 22	13 36 44	- 08 50 24	16 10 15	- 20 56 45	18 53 19	- 23 54 43
22	06 14 44	+ 22 48 47	08 55 09	+ 18 08 58	11 23 22	+ 05 29 28	13 41 26	- 09 18 54	16 15 31	- 21 12 37	18 58 47	- 23 49 19
23	06 19 58	+ 22 49 19	09 00 09	+ 17 50 30	11 27 58	+ 05 00 25	13 46 08	- 09 47 11	16 20 48	- 21 27 53	19 04 15	- 23 43 11
24	06 25 13	+ 22 49 12	09 05 08	+ 17 31 32	11 32 34	+ 04 31 13	13 50 51	- 10 15 15	16 26 06	- 21 42 31	19 09 43	- 23 36 19
25	06 30 28	+ 22 48 25	09 10 06	+ 17 12 04	11 37 09	+ 04 01 52	13 55 35	- 10 43 05	16 31 25	- 21 56 31	19 15 10	- 23 28 44
26	06 35 43	+ 22 47 00	09 15 03	+ 16 52 07	11 41 44	+ 03 32 24	14 00 20	- 11 10 40	16 36 45	- 22 09 53	19 20 36	- 23 20 25
27	06 40 58	+ 22 44 55	09 19 59	+ 16 31 41	11 46 19	+ 03 02 48	14 05 06	- 11 37 59	16 42 06	- 22 22 36	19 26 01	- 23 11 24
28	06 46 13	+ 22 42 10	09 24 54	+ 16 10 47	11 50 54	+ 02 33 07	14 09 53	- 12 05 01	16 47 28	- 22 34 39	19 31 25	- 23 01 40
29	06 51 27	+ 22 38 47	09 29 49	+ 15 49 25	11 55 28	+ 02 03 20	14 14 41	- 12 31 46	16 52 51	- 22 46 02	19 36 49	- 22 51 14
30	06 56 42	+ 22 34 44	09 34 42	+ 15 27 38	12 00 03	+ 01 33 28	14 19 30	- 12 58 13	16 58 15	- 22 56 45	19 42 12	- 22 40 07
31	07 01 57	+ 22 30 02	09 39 34	+ 15 05 24			14 24 20	- 13 24 21			19 47 33	- 22 28 18

VENUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	
Jan 7	06:15	19:55	06:00	19:15	06:03	19:43	07:20	19:52	05:54	20:07	06:14	20:05	06:21	19:50	05:57	19:33	Jan 7
14	05:33	19:07	05:17	18:27	05:20	18:55	06:36	19:06	05:13	19:18	05:32	19:16	05:38	19:02	05:14	18:45	14
21	04:49	18:21	04:34	17:42	04:37	18:09	05:52	18:21	04:30	18:32	04:49	18:30	04:55	18:17	04:31	17:59	21
28	04:11	17:42	03:55	17:03	03:58	17:30	05:13	17:43	03:51	17:53	04:10	17:51	04:16	17:38	03:52	17:20	28
Feb 4	03:39	17:12	03:23	16:33	03:26	17:01	04:41	17:12	03:19	17:23	03:38	17:22	03:45	17:08	03:20	16:50	Feb 4
11	03:15	16:51	02:59	16:11	03:02	16:39	04:18	16:50	02:55	17:02	03:14	17:00	03:21	16:46	02:56	16:28	11
18	02:58	16:36	02:42	15:56	02:45	16:24	04:02	16:35	02:37	16:47	02:57	16:46	03:04	16:32	02:39	16:14	18
25	02:47	16:26	02:31	15:46	02:34	16:15	03:51	16:25	02:26	16:38	02:46	16:36	02:53	16:22	02:28	16:04	25
Mar 4	02:40	16:19	02:25	15:39	02:27	16:08	03:44	16:18	02:20	16:31	02:39	16:29	02:46	16:15	02:21	15:57	Mar 4
11	02:38	16:14	02:22	15:35	02:25	16:03	03:41	16:14	02:18	16:26	02:37	16:24	02:44	16:10	02:19	15:52	11
18	02:39	16:11	02:22	15:32	02:26	15:59	03:40	16:12	02:19	16:21	02:38	16:20	02:44	16:07	02:20	15:48	18
25	02:42	16:07	02:25	15:29	02:29	15:55	03:41	16:11	02:24	16:16	02:42	16:16	02:47	16:04	02:23	15:45	25
Apr 1	02:47	16:03	02:29	15:26	02:35	15:51	03:44	16:10	02:31	16:10	02:48	16:11	02:52	16:00	02:28	15:41	Apr 1
8	02:54	15:59	02:34	15:23	02:42	15:47	03:47	16:10	02:40	16:04	02:55	16:06	02:59	15:56	02:35	15:37	8
15	03:02	15:54	02:41	15:20	02:50	15:42	03:50	16:09	02:50	15:57	03:04	16:01	03:06	15:52	02:42	15:32	15
22	03:11	15:49	02:48	15:17	02:59	15:37	03:54	16:09	03:01	15:50	03:13	15:55	03:14	15:48	02:51	15:27	22
29	03:20	15:43	02:55	15:13	03:08	15:31	03:58	16:08	03:13	15:41	03:24	15:48	03:22	15:43	03:00	15:22	29
May 6	03:30	15:37	03:03	15:09	03:18	15:25	04:03	16:08	03:25	15:33	03:34	15:41	03:31	15:38	03:09	15:16	May 6
13	03:40	15:31	03:11	15:05	03:28	15:19	04:07	16:07	03:38	15:24	03:45	15:35	03:41	15:33	03:19	15:11	13
20	03:51	15:25	03:20	15:01	03:39	15:13	04:12	16:07	03:51	15:16	03:57	15:28	03:51	15:28	03:30	15:05	20
27	04:02	15:20	03:29	14:58	03:50	15:07	04:18	16:08	04:05	15:08	04:09	15:22	04:01	15:23	03:41	15:00	27
Jun 3	04:14	15:15	03:38	14:56	04:02	15:03	04:24	16:09	04:20	15:01	04:22	15:16	04:12	15:20	03:52	14:56	Jun 3
10	04:26	15:12	03:48	14:54	04:14	14:59	04:31	16:11	04:34	14:54	04:35	15:12	04:23	15:17	04:04	14:53	10
17	04:38	15:10	03:59	14:54	04:27	14:57	04:38	16:13	04:49	14:50	04:48	15:09	04:34	15:16	04:16	14:51	17
24	04:51	15:09	04:10	14:55	04:39	14:56	04:46	16:17	05:04	14:47	05:01	15:08	04:46	15:16	04:28	14:51	24
Jul 1	05:03	15:11	04:21	14:58	04:52	14:58	04:55	16:23	05:19	14:46	05:14	15:08	04:58	15:18	04:41	14:52	Jul 1
8	05:16	15:14	04:32	15:03	05:04	15:01	05:04	16:29	05:33	14:48	05:27	15:11	05:10	15:22	04:53	14:56	8
15	05:27	15:20	04:42	15:09	05:16	15:07	05:13	16:37	05:45	14:53	05:39	15:17	05:21	15:28	05:04	15:02	15
22	05:37	15:27	04:52	15:17	05:26	15:14	05:22	16:45	05:56	15:00	05:49	15:24	05:31	15:36	05:14	15:09	22
29	05:46	15:37	05:01	15:27	05:35	15:24	05:31	16:55	06:04	15:10	05:58	15:34	05:40	15:46	05:23	15:19	29
Aug 5	05:52	15:49	05:08	15:38	05:41	15:36	05:40	17:05	06:10	15:22	06:04	15:46	05:47	15:57	05:29	15:30	Aug 5
12	05:57	16:01	05:14	15:49	05:46	15:49	05:47	17:14	06:13	15:37	06:08	15:59	05:52	16:09	05:34	15:43	12
19	06:00	16:15	05:18	16:01	05:48	16:02	05:53	17:24	06:14	15:52	06:10	16:13	05:55	16:22	05:37	15:57	19
26	06:00	16:29	05:20	16:14	05:49	16:17	05:59	17:34	06:12	16:09	06:10	16:28	05:56	16:36	05:38	16:10	26
Sep 2	05:59	16:44	05:21	16:26	05:48	16:31	06:03	17:43	06:08	16:26	06:08	16:44	05:56	16:49	05:37	16:25	Sep 2
9	05:57	16:58	05:21	16:38	05:45	16:46	06:06	17:51	06:03	16:43	06:05	16:59	05:54	17:03	05:35	16:39	9
16	05:53	17:12	05:20	16:50	05:41	17:00	06:09	17:59	05:56	17:01	06:00	17:14	05:52	17:16	05:32	16:53	16
23	05:48	17:27	05:17	17:02	05:36	17:14	06:11	18:07	05:48	17:18	05:54	17:30	05:48	17:29	05:27	17:06	23
30	05:43	17:41	05:15	17:14	05:31	17:29	06:12	18:14	05:40	17:35	05:48	17:45	05:44	17:42	05:22	17:20	30
Oct 7	05:38	17:55	05:12	17:25	05:26	17:43	06:13	18:22	05:31	17:53	05:42	18:00	05:39	17:55	05:17	17:34	Oct 7
14	05:33	18:09	05:09	17:37	05:20	17:57	06:15	18:30	05:23	18:10	05:35	18:16	05:35	18:09	05:13	17:48	14
21	05:28	18:24	05:07	17:50	05:15	18:12	06:17	18:38	05:15	18:28	05:29	18:31	05:31	18:22	05:08	18:02	21
28	05:24	18:39	05:05	18:02	05:11	18:27	06:19	18:46	05:08	18:47	05:24	18:48	05:29	18:36	05:05	18:17	28
Nov 4	05:21	18:55	05:05	18:15	05:08	18:43	06:23	18:55	05:02	19:05	05:21	19:04	05:27	18:51	05:02	18:32	Nov 4
11	05:20	19:10	05:06	18:29	05:07	18:59	06:27	19:05	04:58	19:24	05:18	19:21	05:27	19:06	05:01	18:48	11
18	05:21	19:26	05:08	18:43	05:08	19:15	06:33	19:16	04:56	19:42	05:18	19:37	05:28	19:21	05:02	19:03	18
25	05:24	19:42	05:13	18:57	05:11	19:30	06:41	19:27	04:56	20:00	05:20	19:54	05:32	19:35	05:06	19:18	25
Dec 2	05:29	19:56	05:20	19:10	05:16	19:45	06:49	19:39	05:00	20:16	05:25	20:09	05:38	19:50	05:11	19:33	Dec 2
9	05:37	20:09	05:28	19:22	05:24	19:58	06:59	19:50	05:07	20:31	05:33	20:22	05:46	20:02	05:19	19:46	9
16	05:47	20:21	05:39	19:34	05:34	20:10	07:10	20:01	05:17	20:42	05:43	20:34	05:57	20:14	05:30	19:57	16
23	06:00	20:30	05:51	19:43	05:47	20:19	07:21	20:11	05:30	20:50	05:56	20:42	06:09	20:23	05:42	20:06	23
30	06:14	20:36	06:04	19:51	06:01	20:25	07:33	20:21	05:46	20:55	06:10	20:48	06:23	20:30	05:56	20:13	30

MARS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hr UT Epoch 2000.0

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		RA	DEC
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h m s	Set
Jan 7	14:35	01:03	13:55	00:48	14:24	00:50	14:33	02:08	14:47	00:42	14:45	01:02	14:31	01:09	14:13	00:44	02 38 36	+ 17 09 58
14	14:19	00:42	13:38	00:28	14:08	00:29	14:15	01:49	14:32	00:21	14:29	00:41	14:14	00:48	13:57	00:23	02 47 29	+ 17 54 22
21	14:04	00:22	13:23	00:08	13:53	00:09	13:58	01:31	14:18	23:57	14:15	00:21	13:59	00:29	13:42	00:04	02 57 45	+ 18 41 41
28	13:51	00:03	13:09	23:48	13:39	23:48	13:43	01:14	14:05	23:37	14:01	23:59	13:45	00:10	13:28	23:42	03 09 13	+ 19 30 32
Feb 4	13:38	23:43	12:55	23:31	13:27	23:30	13:29	00:58	13:54	23:19	13:49	23:41	13:33	23:50	13:15	23:25	03 21 43	+ 20 19 39
11	13:27	23:27	12:43	23:15	13:15	23:14	13:16	00:43	13:43	23:01	13:38	23:24	13:21	23:34	13:04	23:08	03 35 09	+ 21 07 47
18	13:16	23:11	12:32	23:00	13:05	22:58	13:03	00:29	13:33	22:44	13:28	23:08	13:10	23:19	12:53	22:53	03 49 23	+ 21 53 44
25	13:06	22:56	12:21	22:45	12:55	22:43	12:51	00:15	13:24	22:29	13:18	22:53	12:59	23:04	12:43	22:38	04 04 18	+ 22 36 32
Mar 4	12:56	22:42	12:10	22:32	12:45	22:29	12:40	00:02	13:15	22:14	13:08	22:38	12:49	22:50	12:33	22:24	04 19 51	+ 23 15 21
11	12:46	22:28	12:00	22:19	12:35	22:15	12:29	23:49	13:06	21:59	12:59	22:25	12:40	22:37	12:23	22:10	04 35 57	+ 23 49 20
18	12:37	22:16	11:51	22:07	12:26	22:03	12:18	23:37	12:57	21:46	12:50	22:12	12:30	22:24	12:14	21:58	04 52 30	+ 24 17 44
25	12:28	22:04	11:41	21:55	12:16	21:51	12:08	23:26	12:49	21:34	12:40	22:00	12:20	22:13	12:04	21:46	05 09 27	+ 24 39 59
Apr 1	12:18	21:53	11:31	21:44	12:07	21:39	11:58	23:16	12:40	21:22	12:31	21:48	12:11	22:02	11:55	21:35	05 26 45	+ 24 55 35
8	12:09	21:42	11:22	21:34	11:58	21:29	11:48	23:05	12:30	21:12	12:22	21:38	12:01	21:51	11:45	21:24	05 44 18	+ 25 04 07
15	11:59	21:32	11:12	21:24	11:48	21:19	11:38	22:56	12:20	21:02	12:12	21:28	11:52	21:41	11:35	21:15	06 02 04	+ 25 05 13
22	11:49	21:23	11:02	21:15	11:38	21:10	11:29	22:46	12:10	20:53	12:02	21:19	11:42	21:32	11:25	21:05	06 19 58	+ 24 58 43
29	11:38	21:14	10:52	21:06	11:27	21:01	11:19	22:37	11:59	20:44	11:51	21:10	11:31	21:23	11:15	20:57	06 37 58	+ 24 44 29
May 6	11:28	21:06	10:41	20:57	11:16	20:53	11:09	22:28	11:48	20:37	11:40	21:02	11:21	21:15	11:04	20:48	06 56 01	+ 24 22 26
13	11:16	20:58	10:30	20:49	11:05	20:45	10:59	22:19	11:36	20:30	11:29	20:55	11:09	21:07	10:53	20:40	07 14 02	+ 23 52 39
20	11:04	20:51	10:19	20:41	10:53	20:38	10:48	22:10	11:23	20:23	11:17	20:48	10:58	20:59	10:41	20:33	07 32 01	+ 23 15 16
27	10:52	20:44	10:08	20:33	10:41	20:31	10:38	22:01	11:10	20:17	11:04	20:41	10:46	20:52	10:29	20:26	07 49 54	+ 22 30 26
Jun 3	10:39	20:37	09:56	20:25	10:28	20:24	10:27	21:52	10:56	20:11	10:51	20:34	10:34	20:45	10:17	20:19	08 07 40	+ 21 38 25
10	10:26	20:30	09:43	20:18	10:15	20:17	10:16	21:43	10:42	20:05	10:37	20:28	10:21	20:37	10:03	20:12	08 25 18	+ 20 39 30
17	10:13	20:24	09:31	20:10	10:01	20:11	10:05	21:34	10:27	20:00	10:23	20:22	10:07	20:31	09:50	20:05	08 42 46	+ 19 34 05
24	09:58	20:17	09:17	20:03	09:47	20:04	09:54	21:25	10:12	19:55	10:09	20:16	09:54	20:24	09:36	19:58	09 00 05	+ 18 22 28
Jul 1	09:44	20:11	09:04	19:55	09:33	19:58	09:42	21:15	09:56	19:50	09:54	20:10	09:40	20:17	09:22	19:52	09 17 14	+ 17 05 04
8	09:29	20:04	08:50	19:48	09:18	19:52	09:30	21:06	09:39	19:45	09:39	20:04	09:25	20:10	09:07	19:45	09 34 13	+ 15 42 19
15	09:14	19:58	08:36	19:40	09:02	19:45	09:18	20:57	09:23	19:40	09:23	19:58	09:11	20:03	08:52	19:39	09 51 03	+ 14 14 41
22	08:59	19:52	08:22	19:33	08:47	19:39	09:06	20:47	09:06	19:36	09:07	19:52	08:56	19:56	08:37	19:32	10 07 44	+ 12 42 34
29	08:43	19:45	08:08	19:25	08:31	19:33	08:53	20:38	08:48	19:31	08:51	19:46	08:40	19:49	08:21	19:26	10 24 19	+ 11 06 23
Aug 5	08:27	19:39	07:53	19:18	08:15	19:27	08:41	20:28	08:31	19:26	08:34	19:41	08:25	19:43	08:05	19:19	10 40 49	+ 09 26 39
12	08:11	19:33	07:38	19:10	07:59	19:20	08:28	20:18	08:13	19:22	08:18	19:35	08:10	19:36	07:50	19:13	10 57 13	+ 07 43 51
19	07:55	19:26	07:23	19:03	07:43	19:14	08:15	20:09	07:55	19:17	08:01	19:29	07:54	19:29	07:34	19:06	11 13 36	+ 05 58 24
26	07:38	19:20	07:08	18:55	07:27	19:08	08:02	19:59	07:38	19:12	07:44	19:24	07:38	19:22	07:18	19:00	11 29 58	+ 04 10 47
Sep 2	07:22	19:14	06:53	18:48	07:10	19:02	07:50	19:49	07:20	19:08	07:27	19:18	07:22	19:16	07:01	18:54	11 46 22	+ 02 21 29
9	07:06	19:08	06:38	18:41	06:54	18:56	07:37	19:40	07:02	19:04	07:10	19:13	07:07	19:09	06:45	18:48	12 02 49	+ 00 31 05
16	06:50	19:02	06:23	18:33	06:38	18:50	07:24	19:31	06:44	19:00	06:54	19:07	06:51	19:03	06:29	18:42	12 19 23	- 01 19 58
23	06:34	18:57	06:09	18:26	06:22	18:45	07:12	19:21	06:26	18:56	06:37	19:02	06:36	18:57	06:14	18:36	12 36 04	- 03 11 08
30	06:18	18:51	05:54	18:20	06:06	18:39	06:59	19:12	06:08	18:52	06:21	18:57	06:20	18:50	05:58	18:30	12 52 56	- 05 01 51
Oct 7	06:02	18:46	05:40	18:13	05:50	18:34	06:47	19:03	05:51	18:48	06:04	18:52	06:05	18:45	05:42	18:24	13 10 01	- 06 51 27
14	05:47	18:41	05:26	18:07	05:34	18:29	06:35	18:55	05:34	18:45	05:48	18:48	05:50	18:39	05:27	18:19	13 27 21	- 08 39 22
21	05:32	18:36	05:12	18:00	05:19	18:24	06:24	18:46	05:17	18:42	05:33	18:44	05:36	18:34	05:12	18:14	13 44 59	- 10 24 58
28	05:17	18:31	04:58	17:55	05:04	18:20	06:13	18:38	05:01	18:39	05:18	18:40	05:22	18:28	04:58	18:09	14 02 56	- 12 07 31
Nov 4	05:03	18:27	04:46	17:49	04:50	18:15	06:02	18:31	04:45	18:36	05:03	18:36	05:08	18:24	04:44	18:05	14 21 15	- 13 46 17
11	04:49	18:23	04:33	17:44	04:36	18:11	05:51	18:23	04:30	18:34	04:49	18:32	04:55	18:19	04:30	18:01	14 39 57	- 15 20 29
18	04:36	18:19	04:21	17:39	04:23	18:08	05:41	18:16	04:15	18:31	04:35	18:29	04:42	18:15	04:17	17:57	14 59 05	- 16 49 24
25	04:24	18:15	04:10	17:34	04:11	18:04	05:32	18:10	04:01	18:29	04:22	18:26	04:30	18:10	04:05	17:53	15 18 38	- 18 12 09
Dec 2	04:12	18:12	03:59	17:29	03:59	18:00	05:23	18:03	03:48	18:27	04:10	18:23	04:19	18:06	03:54	17:49	15 38 38	- 19 27 53
9	04:01	18:08	03:49	17:25	03:48	17:57	05:15	17:57	03:36	18:25	03:59	18:20	04:09	18:03	03:43	17:46	15 59 04	- 20 35 46
16	03:51	18:05	03:40	17:20	03:38	17:54	05:07	17:52	03:24	18:23	03:48	18:17	03:59	17:59	03:33	17:42	16 19 57	- 21 35 00
23	03:42	18:02	03:32	17:16	03:29	17:50	05:00	17:46	03:14	18:21	03:39	18:14	03:50	17:55	03:24	17:38	16 41 15	- 22 24 46
30	03:34	17:58	03:24	17:12	03:21	17:47	04:53	17:41	03:05	18:18	03:30	18:10	03:42	17:51	03:16	17:35	17 02 55	- 23 04 19

JUPITER'S MOONS 2006

Jupiter, with its many moons orbiting the planet, can be likened to a miniature Solar System. Also, like the planets, these moons all lie in a similar plane. Although there are currently 63 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo (who suggested calling them the 'Medicean Stars'), are bright enough to be visible in small telescopes, moderate-sized binoculars or even the naked eye (see page 27). The dance of these moons, as they pass back and forth across Jupiter, is illustrated in 'Jupiter's Moons' on pages 114 – 115. All the moons orbit in roughly the same plane, which is very close to the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From our perspective on Earth, we see four types of events. They are:

1 The satellite passes in front of Jupiter. This is called a Satellite Transit.

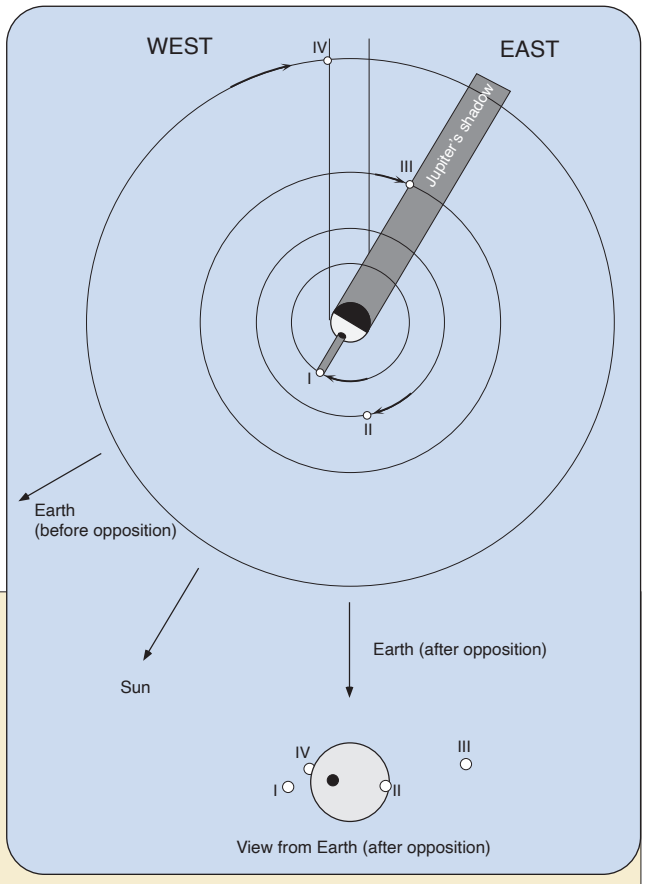
2 The shadow of a satellite can move across the 'surface' of the planet. This is called a Satellite Shadow Transit. The start of a satellite or shadow transit is called its ingress; the finish, its egress.

Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter's opposition date in 2006 is May 5 EST.

3 A satellite can go into occultation i.e., pass behind the disc of Jupiter.

4 A satellite can be eclipsed as it passes into Jupiter's shadow. The closer Jupiter is to opposition (or conjunction), the more likely the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7X or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation, see also page 27). This happens every eight days approximately; an example would be the morning of January 7. To see the moons with binoculars may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.



This diagram illustrates all of the Jupiter satellite events. It is only an example and does not represent any particular date.

Viewed from the Earth (after opposition):

Satellite I	(Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.
Satellite II	(Europa) has just commenced a satellite transit (ingress).
Satellite III	(Ganymede) is about to be eclipsed (disappear).
Satellite IV	(Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

JUPITER'S MOON EVENTS Legend (pp. 111-113)

Column 1	Date (only appears for the first event each day).
Column 2	Time in EST.
Column 3	Time in WST, a (p) after the time means it is on the previous day.
Column 4	I = Io, II = Europa, III = Ganymede, IV = Callisto
Column 5	Oc = Occultation, Sh = Shadow Transit, Tr = Satellite Transit, Ec = Eclipse
Column 6	I = Ingress, E = Egress, D = Disappearance, R = Reappearance
Column 7	Visibility where 'E' indicates the event is more suitable for the eastern states, 'W' is for events more suitable for observation from Western Australia. A blank here means the event is suitable for most of Australia.

Note: In these tables, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia. Events near conjunction i.e., with Jupiter closer than 18° to the Sun, have been omitted.

ECLIPSE POSITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Io (I)	d	d	d	d	r	r	r	r	r	r	r	d
Europa (II)	d	d	d	d	r	r	r	r	r	r	r	d
Ganymede (III)	d r	d r	d r	d r	r	d r	d r	d r	d r	d r	r	d
Callisto (IV)	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse	no eclipse

These diagrams shows the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse is when the moon passes into (disappearance or 'd') or out of (reappearance or 'r') Jupiter's shadow; west to the left, east to the right.

JUPITER MOON EVENTS

January

1	01:30	23:30(p)	I	Ec	D	E
	04:25	02:25	II	Oc	R	
	04:41	02:41	I	Oc	R	
2	01:55	23:55(p)	I	Tr	E	E
6	06:08	04:08	III	Ec	D	W
7	06:07	04:07	I	Sh	I	W
8	02:19	00:19	II	Ec	D	
	03:23	01:23	I	Ec	D	
	06:37	04:37	I	Oc	R	W
9	01:43	23:43(p)	I	Tr	I	E
	02:46	00:46	I	Sh	E	
	03:52	01:52	I	Tr	E	
10	01:06	23:06(p)	I	Oc	R	E
	01:45	23:45(p)	II	Tr	E	E
	02:19	00:19	III	Tr	E	
15	04:55	02:55	II	Ec	D	
	05:16	03:16	I	Ec	D	
16	02:29	00:29	I	Sh	I	
	03:40	01:40	I	Tr	I	
	04:40	02:40	I	Sh	E	
	05:49	03:49	I	Tr	E	W
17	01:52	23:52(p)	II	Tr	I	
	01:52	23:52(p)	III	Sh	E	
	02:07	00:07	II	Sh	E	
	03:02	01:02	I	Oc	R	
	04:23	02:23	II	Tr	E	
	04:45	02:45	III	Tr	I	
	06:27	04:27	III	Tr	E	W
18	00:18	22:18(p)	I	Tr	E	E
22	07:08	05:08	I	Ec	D	W
23	04:23	02:23	I	Sh	I	
	05:36	03:36	I	Tr	I	
	06:33	04:33	I	Sh	E	W
24	01:37	23:37(p)	I	Ec	D	
	02:06	00:06	II	Sh	I	
	03:52	01:52	III	Sh	I	
	04:30	02:30	II	Tr	I	
	04:40	02:40	II	Sh	E	
	04:57	02:57	I	Oc	R	
	05:50	03:50	III	Sh	E	W
	07:00	05:00	II	Tr	E	W
25	00:04	22:04(p)	I	Tr	I	E
	01:01	23:01(p)	I	Sh	E	E
	02:14	00:14	I	Tr	E	
26	01:51	23:51(p)	II	Oc	R	
28	00:44	22:44(p)	III	Oc	R	E
30	06:16	04:16	I	Sh	I	W
31	03:29	01:29	I	Ec	D	
	04:39	02:39	II	Sh	I	
	06:51	04:51	I	Oc	R	W
	07:05	05:05	II	Tr	I	W
	07:12	05:12	II	Sh	E	W

February

1	00:44	22:44(p)	I	Sh	I	E
	01:59	23:59(p)	I	Tr	I	
	02:55	00:55	I	Sh	E	
	04:08	02:08	I	Tr	E	
	23:25	21:25	II	Ec	D	E
2	01:20	23:20(p)	I	Oc	R	
	04:29	02:29	II	Oc	R	
3	23:55	21:55	III	Ec	R	E
4	03:07	01:07	III	Oc	D	
	04:43	02:43	III	Oc	R	
7	05:22	03:22	I	Ec	D	
	07:12	05:12	II	Sh	I	W
8	02:38	00:38	I	Sh	I	
	03:53	01:53	I	Tr	I	
	04:48	02:48	I	Sh	E	
	06:02	04:02	I	Tr	E	W
	23:50	21:50	I	Ec	D	E
9	02:00	00:00	II	Ec	D	
	03:13	01:13	I	Oc	R	
	07:05	05:05	II	Oc	R	W
	23:16	21:16	I	Sh	E	E
10	00:30	22:30(p)	I	Tr	E	
	22:56	20:56	II	Tr	I	E
	23:01	21:01	II	Sh	E	E
11	01:25	23:25(p)	II	Tr	E	
	01:54	23:54(p)	III	Ec	D	
	03:52	01:52	III	Ec	R	
	07:06	05:06	III	Oc	D	W
14	07:15	05:15	I	Ec	D	W
15	04:31	02:31	I	Sh	I	
	05:46	03:46	I	Tr	I	
	06:41	04:41	I	Sh	E	W
16	01:43	23:43(p)	I	Ec	D	
	04:36	02:36	II	Ec	D	
	05:05	03:05	I	Oc	R	
	23:00	21:00	I	Sh	I	E
17	00:14	22:14(p)	I	Tr	I	
	01:10	23:10(p)	I	Sh	E	
	02:23	00:23	I	Tr	E	
	23:01	21:01	II	Sh	I	E
	23:33	21:33	I	Oc	R	E
18	01:27	23:27(p)	II	Tr	I	
	01:34	23:34(p)	II	Sh	E	
	03:56	01:56	II	Tr	E	
	05:52	03:52	III	Ec	D	
19	22:54	20:54	II	Oc	R	E
22	00:51	22:51(p)	III	Tr	I	
	02:15	00:15	III	Tr	E	
	06:25	04:25	I	Sh	I	W
	07:38	05:38	I	Tr	I	W
23	03:36	01:36	I	Ec	D	
	06:56	04:56	I	Oc	R	W
	07:11	05:11	II	Ec	D	W
24	00:53	22:53(p)	I	Sh	I	
	02:06	00:06	I	Tr	I	
	03:03	01:03	I	Sh	E	
	04:14	02:14	I	Tr	E	
	22:04	20:04	I	Ec	D	E
25	01:24	23:24(p)	I	Oc	R	
	01:34	23:34(p)	II	Sh	I	
	03:56	01:56	II	Tr	I	
	04:07	02:07	II	Sh	E	
	06:25	04:25	II	Tr	E	W
	22:42	20:42	I	Tr	E	E
27	01:24	23:24(p)	II	Oc	R	
28	23:40	21:40	III	Sh	I	

March

1	01:35	23:35(p)	III	Sh	E	
	04:39	02:39	III	Tr	I	
	05:59	03:59	III	Tr	E	
2	05:29	03:29	I	Ec	D	
3	02:47	00:47	I	Sh	I	
	03:56	01:56	I	Tr	I	
	04:57	02:57	I	Sh	E	
	06:05	04:05	I	Tr	E	
	23:57	21:57	I	Ec	D	
4	03:13	01:13	I	Oc	R	
	04:06	02:06	II	Sh	I	
	06:23	04:23	II	Tr	I	W
	06:40	04:40	II	Sh	E	W
	22:24	20:24	I	Tr	I	E
	23:25	21:25	I	Sh	E	
5	00:32	22:32(p)	I	Tr	E	
	21:41	19:41	I	Oc	R	E
	23:04	21:04	II	Ec	D	
6	03:53	01:53	II	Oc	R	
7	22:04	20:04	II	Tr	E	E
8	03:38	01:38	III	Sh	I	
	05:32	03:32	III	Sh	E	
9	07:22	05:22	I	Ec	D	W
10	04:40	02:40	I	Sh	I	
	05:46	03:46	I	Tr	I	
	06:50	04:50	I	Sh	E	W
11	01:50	23:50(p)	I	Ec	D	
	05:02	03:02	I	Oc	R	
	06:40	04:40	II	Sh	I	W
	22:19	20:19	III	Oc	D	E
	23:08	21:08	I	Sh	I	
	23:37	21:37	III	Oc	R	
12	00:13	22:13(p)	I	Tr	I	
	01:18	23:18(p)	I	Sh	E	
	02:21	00:21	I	Tr	E	
	23:29	21:29	I	Oc	R	
13	01:40	23:40(p)	II	Ec	D	
	06:18	04:18	II	Oc	R	
	20:48	18:48	I	Tr	E	E
14	22:00	20:00	II	Tr	I	E
	22:29	20:29	II	Sh	E	
15	00:28	22:28(p)	II	Tr	E	
	07:36	05:36	III	Sh	I	W
17	06:34	04:34	I	Sh	I	W
	07:34	05:34	I	Tr	I	W
18	03:43	01:43	I	Ec	D	
	06:50	04:50	I	Oc	R	W
	21:42	19:42	III	Ec	D	E
	23:37	21:37	III	Ec	R	
19	01:02	23:02(p)	I	Sh	I	
	01:55	23:55(p)	III	Oc	D	
	02:01	00:01	I	Tr	I	
	03:10	01:10	III	Oc	R	
	03:12	01:12	I	Sh	E	
	04:09	02:09	I	Tr	E	
	22:11	20:11	I	Ec	D	
20	01:17	23:17(p)	I	Oc	R	
	04:15	02:15	II	Ec	D	
	20:28	18:28	I	Tr	I	E
	21:40	19:40	I	Sh	E	E
	22:36	20:36	I	Tr	E	
21	22:30	20:30	II	Sh	I	
22	00:22	22:22(p)	II	Tr	I	
	01:03	23:03(p)	II	Sh	E	
	02:49	00:49	II	Tr	E	
23	21:53	19:53	II	Oc	R	
25	05:36	03:36	I	Ec	D	
26	01:39	23:39(p)	III	Ec	D	
	02:56	00:56	I	Sh	I	
	03:33	01:33	III	Ec	R	
	03:48	01:48	I	Tr	I	
	05:05	03:05	I	Sh	E	
	05:26	03:26	III	Oc	D	
	05:56	03:56	I	Tr	E	
	06:39	04:39	III	Oc	R	W
27	00:04	22:04(p)	I	Ec	D	
	03:03	01:03	I	Oc	R	
	06:51	04:51	II	Ec	D	W
	21:24	19:24	I	Sh	I	
	22:15	20:15	I	Tr	I	
	23:34	21:34	I	Sh	E	
28	00:22	22:22(p)	I	Tr	E	
	21:30	19:30	I	Oc	R	
29	01:03	23:03(p)	II	Sh	I	
	02:42	00:42	II	Tr	I	
	03:36	01:36	II	Sh	E	
	05:09	03:09	II	Tr	E	
	20:16	18:16	III	Tr	E	E
30	20:09	18:09	II	Ec	D	E
31	00:14	22:14(p)	II	Oc	R	

April

1	07:29	05:29	I	Ec	D	W
2	04:49	02:49	I	Sh	I	
	05:34	03:34	I	Tr	I	
	05:36	03:36	III	Ec	D	
	06:59	04:59	I	Sh	E	W
	07:30	05:30	III	Ec	R	W
	07:42	05:42	I	Tr	E	W
3	01:58	23:58(p)	I	Ec	D	
	04:49	02:49	I	Oc	R	
	23:18	21:18	I	Sh	I	
4	00:00	22:00(p)	I	Tr	I	
	01:27	23:27(p)	I	Sh	E	
	02:08	00:08	I	Tr	E	
	20:26	18:26	I	Ec	D	E
	23:15	21:15	I	Oc	R	
5	03:37	01:37	II	Sh	I	
	05:00	03:00	II	Tr	I	
	06:10	04:10	II	Sh	E	
	07:27	05:27	II	Tr	E	W
	19:30	17:30	III	Sh	I	E
	19:56	17:56	I	Sh	E	E
	20:35	18:35	I	Tr	E	E
	21:22	19:22	III	Sh	E	
	22:32	20:32	III	Tr	I	
	23:41	21:41	III	Tr	E	
6	22:44	20:44	II	Ec	D	
7	02:32	00:32	II	Oc	R	
8	19:27	17:27	II	Sh	E	E
	20:36	18:36	II	Tr	E	
9	06:43	04:43	I	Sh	I	W
	07:19	05:19	I	Tr	I	W
10	03:51	01:51	I	Ec	D	
	06:34	04:34	I	Oc	R	
11	01:11	23:11(p)	I	Sh	I	
	01:46	23:46(p)	I	Tr	I	
	03:21	01:21	I	Sh	E	
	03:53	01:53	I	Tr	E	
	22:19	20:19	I	Ec	D	
12	01:00	23:00(p)	I	Oc	R	
	06:11	04:11	II	Sh	I	
	07:17	05:17	II	Tr	I	W
	19:40	17:40	I	Sh	I	E
	20:12	18:12	I	Tr	I	
	21:49	19:49	I	Sh	E	
	22:19	20:19	I	Tr	E	
	23:28	21:28	III	Sh	I	
13	01:20	23:20(p)	III	Sh	E	
	01:53	23:53(p)	III	Tr	I	
	03:03	01:03	III	Tr	E	
	19:26	17:26	I	Oc	R	E
14	01:19	23:19(p)	II	Ec	D	
	04:49	02:49	II	Oc	R	

JUPITER MOON EVENTS

15	19:28	17:28	II	Sh	I	E
	20:25	18:25	II	Tr	I	
	22:01	20:01	II	Sh	E	
	22:52	20:52	II	Tr	E	
17	05:45	03:45	I	Ec	D	
	08:18	06:18	I	Oc	R	W
18	03:05	01:05	I	Sh	I	
	03:30	01:30	I	Tr	I	
	05:15	03:15	I	Sh	E	
	05:38	03:38	I	Tr	E	
19	00:13	22:13(p)	I	Ec	D	
	02:44	00:44	I	Oc	R	
	21:34	19:34	I	Sh	I	
	21:56	19:56	I	Tr	I	
	23:43	21:43	I	Sh	E	
20	00:04	22:04(p)	I	Tr	E	
	03:26	01:26	III	Sh	I	
	05:11	03:11	III	Tr	I	
	05:17	03:17	III	Sh	E	
	06:22	04:22	III	Tr	E	
	18:42	16:42	I	Ec	D	E
	21:10	19:10	I	Oc	R	
21	03:55	01:55	II	Ec	D	
	07:05	05:05	II	Oc	R	W
	18:12	16:12	I	Sh	E	E
	18:30	16:30	I	Tr	E	E
22	22:03	20:03	II	Sh	I	
	22:40	20:40	II	Tr	I	
23	00:36	22:36(p)	II	Sh	E	
	01:07	23:07(p)	II	Tr	E	
	20:10	18:10	III	Oc	R	
24	07:38	05:38	I	Ec	D	W
	20:13	18:13	II	Oc	R	
25	04:59	02:59	I	Sh	I	
	05:14	03:14	I	Tr	I	
	07:09	05:09	I	Sh	E	W
	07:22	05:22	I	Tr	E	W
26	02:07	00:07	I	Ec	D	
	04:28	02:28	I	Oc	R	
	23:28	21:28	I	Sh	I	
	23:40	21:40	I	Tr	I	
27	01:37	23:37(p)	I	Sh	E	
	01:48	23:48(p)	I	Tr	E	
	07:24	05:24	III	Sh	I	W
	08:27	06:27	III	Tr	I	W
	20:35	18:35	I	Ec	D	
	22:54	20:54	I	Oc	R	
28	06:30	04:30	II	Ec	D	
	17:56	15:56	I	Sh	I	E
	18:06	16:06	I	Tr	I	E
	20:06	18:06	I	Sh	E	
	20:14	18:14	I	Tr	E	
30	00:37	22:37(p)	II	Sh	I	
	00:54	22:54(p)	II	Tr	I	
	03:10	01:10	II	Sh	E	
	03:22	01:22	II	Tr	E	
	21:30	19:30	III	Ec	D	
	23:29	21:29	III	Oc	R	

May

1	19:47	17:47	II	Ec	D	
	22:28	20:28	II	Oc	R	
2	06:53	04:53	I	Sh	I	W
	06:58	04:58	I	Tr	I	W
3	04:01	02:01	I	Ec	D	
	06:12	04:12	I	Oc	R	
4	01:22	23:22(p)	I	Sh	I	
	01:24	23:24(p)	I	Tr	I	
	03:31	01:31	I	Sh	E	
	03:32	01:32	I	Tr	E	
	22:29	20:29	I	Ec	D	
5	00:39	22:39(p)	I	Ec	R	
	19:50	17:50	I	Tr	I	
	19:50	17:50	I	Sh	I	
	21:58	19:58	I	Tr	E	
	22:00	20:00	I	Sh	E	
6	19:07	17:07	I	Ec	R	E
7	03:08	01:08	II	Tr	I	
	03:12	01:12	II	Sh	I	
	05:37	03:37	II	Tr	E	
	05:45	03:45	II	Sh	E	
8	01:24	23:24(p)	III	Oc	D	
	03:19	01:19	III	Ec	R	
	22:13	20:13	II	Oc	D	
9	00:56	22:56(p)	II	Ec	R	
10	05:48	03:48	I	Oc	D	
	08:04	06:04	I	Ec	R	W
	18:44	16:44	II	Tr	E	E
	19:03	17:03	II	Sh	E	E
11	03:07	01:07	I	Tr	I	
	03:16	01:16	I	Sh	I	
	05:16	03:16	I	Tr	E	
	05:25	03:25	I	Sh	E	
	17:11	15:11	III	Sh	E	E
12	00:14	22:14(p)	I	Oc	D	
	02:33	00:33	I	Ec	R	
	21:33	19:33	I	Tr	I	
	21:44	19:44	I	Sh	I	
	23:42	21:42	I	Tr	E	
	23:54	21:54	I	Sh	E	
13	18:40	16:40	I	Oc	D	E
	21:02	19:02	I	Ec	R	
14	05:23	03:23	II	Tr	I	
	05:48	03:48	II	Sh	I	W
	07:52	05:52	II	Tr	E	W
	18:08	16:08	I	Tr	E	E
	18:22	16:22	I	Sh	E	E
15	04:39	02:39	III	Oc	D	
	07:17	05:17	III	Ec	R	W
16	00:28	22:28(p)	II	Oc	D	
	03:31	01:31	II	Ec	R	
17	07:32	05:32	I	Oc	D	W
	18:30	16:30	II	Tr	I	E
	19:06	17:06	II	Sh	I	
	21:00	19:00	II	Tr	E	
	21:39	19:39	II	Sh	E	
18	04:52	02:52	I	Tr	I	
	05:10	03:10	I	Sh	I	
	07:00	05:00	I	Tr	E	W
	07:19	05:19	I	Sh	E	W
	18:12	16:12	III	Tr	I	E
	19:20	17:20	III	Sh	I	
	19:39	17:39	III	Tr	E	
	21:10	19:10	III	Sh	E	
19	01:58	23:58(p)	I	Oc	D	
	04:27	02:27	I	Ec	R	
	16:49	14:49	II	Ec	R	E
	23:18	21:18	I	Tr	I	
	23:38	21:38	I	Sh	I	
20	01:26	23:26(p)	I	Tr	E	
	01:48	23:48(p)	I	Sh	E	
	20:24	18:24	I	Oc	D	
	22:56	20:56	I	Ec	R	
21	17:44	15:44	I	Tr	I	E
	18:07	16:07	I	Sh	I	E
	19:52	17:52	I	Tr	E	
	20:16	18:16	I	Sh	E	
22	17:24	15:24	I	Ec	R	E
23	02:43	00:43	II	Oc	D	
	06:06	04:06	II	Ec	R	W
24	20:46	18:46	II	Tr	I	
	21:41	19:41	II	Sh	I	
	23:16	21:16	II	Tr	E	
25	00:14	22:14(p)	II	Sh	E	
	06:36	04:36	I	Tr	I	W
	07:04	05:04	I	Sh	I	W
	21:29	19:29	III	Tr	I	
	23:00	21:00	III	Tr	E	
	23:19	21:19	III	Sh	I	
26	01:08	23:08(p)	III	Sh	E	
	03:43	01:43	I	Oc	D	
	06:22	04:22	I	Ec	R	W
	19:24	17:24	II	Ec	R	
27	01:02	23:02(p)	I	Tr	I	
	01:33	23:33(p)	I	Sh	I	
	03:11	01:11	I	Tr	E	
	03:42	01:42	I	Sh	E	
	22:09	20:09	I	Oc	D	
28	00:50	22:50(p)	I	Ec	R	
	19:29	17:29	I	Tr	I	
	20:01	18:01	I	Sh	I	
	21:37	19:37	I	Tr	E	
	22:11	20:11	I	Sh	E	
29	19:19	17:19	I	Ec	R	
30	05:00	03:00	II	Oc	D	W
	16:39	14:39	I	Sh	E	E
31	23:03	21:03	II	Tr	I	

June

1	00:17	22:17(p)	II	Sh	I	
	01:34	23:34(p)	II	Tr	E	
	02:50	00:50	II	Sh	E	
2	00:48	22:48(p)	III	Tr	I	
	02:24	00:24	III	Tr	E	
	03:17	01:17	III	Sh	I	
	05:06	03:06	III	Sh	E	W
	05:28	03:28	I	Oc	D	W
	18:08	16:08	II	Oc	D	E
	21:59	19:59	II	Ec	R	
3	02:48	00:48	I	Tr	I	
	03:27	01:27	I	Sh	I	
	04:56	02:56	I	Tr	E	W
	05:36	03:36	I	Sh	E	W
	23:55	21:55	I	Oc	D	
4	02:45	00:45	I	Ec	R	
	21:14	19:14	I	Tr	I	
	21:56	19:56	I	Sh	I	
	23:23	21:23	I	Tr	E	
5	00:05	22:05(p)	I	Sh	E	
	17:22	15:22	III	Ec	D	E
	18:21	16:21	I	Oc	D	E
	19:13	17:13	III	Ec	R	
	21:14	19:14	I	Ec	R	
6	17:50	15:50	I	Tr	E	E
	18:34	16:34	I	Sh	E	E
8	01:22	23:22(p)	II	Tr	I	
	02:54	00:54	II	Sh	I	
	03:54	01:54	II	Tr	E	W
	05:27	03:27	II	Sh	E	W
9	04:10	02:10	III	Tr	I	W
	05:51	03:51	III	Tr	E	W
	20:27	18:27	II	Oc	D	
10	00:34	22:34(p)	II	Ec	R	
	04:34	02:34	I	Tr	I	W
	05:22	03:22	I	Sh	I	W
11	01:41	23:41(p)	I	Oc	D	
	04:40	02:40	I	Ec	R	W
	17:04	15:04	II	Tr	E	E
	18:45	16:45	II	Sh	E	E
	23:01	21:01	I	Tr	I	
	23:50	21:50	I	Sh	I	
12	01:10	23:10(p)	I	Tr	E	
	01:59	23:59(p)	I	Sh	E	
	18:00	16:00	III	Oc	D	E
	19:45	17:45	III	Oc	R	
	20:08	18:08	I	Oc	D	
	21:22	19:22	III	Ec	D	
	23:08	21:08	I	Ec	R	
	23:12	21:12	III	Ec	R	
13	17:28	15:28	I	Tr	I	E
	18:19	16:19	I	Sh	I	E
	19:36	17:36	I	Tr	E	
	20:28	18:28	I	Sh	E	
14	17:37	15:37	I	Ec	R	E
15	03:43	01:43	II	Tr	I	W
	05:30	03:30	II	Sh	I	W
16	22:48	20:48	II	Oc	D	
17	03:09	01:09	II	Ec	R	
18	03:29	01:29	I	Oc	D	W
	16:54	14:54	II	Tr	I	E
	18:48	16:48	II	Sh	I	E
	19:27	17:27	II	Tr	E	
	21:21	19:21	II	Sh	E	
19	00:48	22:48(p)	I	Tr	I	
	01:45	23:45(p)	I	Sh	I	
	02:57	00:57	I	Tr	E	
	03:54	01:54	I	Sh	E	W
	21:29	19:29	III	Oc	D	
	21:56	19:56	I	Oc	D	
	23:18	21:18	III	Oc	R	
20	01:03	23:03(p)	I	Ec	R	
	01:21	23:21(p)	III	Ec	D	
	03:11	01:11	III	Ec	R	W
	19:15	17:15	I	Tr	I	
	20:13	18:13	I	Sh	I	
	21:24	19:24	I	Tr	E	
	22:23	20:23	I	Sh	E	
21	19:32	17:32	I	Ec	R	
22	16:51	14:51	I	Sh	E	E
23	17:03	15:03	III	Sh	E	E
24	01:10	23:10(p)	II	Oc	D	
25	19:18	17:18	II	Tr	I	
	21:25	19:25	II	Sh	I	
	21:52	19:52	II	Tr	E	
	23:58	21:58	II	Sh	E	
26	02:37	00:37	I	Tr	I	W
	03:39	01:39	I	Sh	I	W
	04:46	02:46	I	Tr	E	W
	23:45	21:45	I	Oc	D	
27	01:02	23:02(p)	III	Oc	D	
	02:55	00:55	III	Oc	R	W
	02:58	00:58	I	Ec	R	W
	19:01	17:01	II	Ec	R	
	21:04	19:04	I	Tr	I	
	22:08	20:08	I	Sh	I	
	23:13	21:13	I	Tr	E	
28	00:17	22:17(p)	I	Sh	E	
	18:12	16:12	I	Oc	D	E
	21:27	19:27	I	Ec	R	

29	17:41	15:41	I	Tr	E	E	
	18:46	16:46	I	Sh	E	E	
30	19:13	17:13	III	Sh	I		
	21:01	19:01	III	Sh	E		

July

1	03:34	01:34	II	Oc	D	W	
2	21:45	19:45	II	Tr	I		
3	00:02	22:02(p)	II	Sh	I		
	00:19	22:19(p)	II	Tr	E		
	02:35	00:35	II	Sh	E	W	
	04:27	02:27	I	Tr	I	W	
4	01:35	23:35(p)	I	Oc	D		
	16:47	14:47	II	Oc	D	E	
	21:36	19:36	II	Ec	R		
	22:54	20:54	I	Tr	I		
5	00:03	22:03(p)	I	Sh	I		
	01:04	23:04(p)	I	Tr	E		
	02:12	00:12	I	Sh	E	W	
	20:03	18:03	I	Oc	D		
	23:22	21:22	I	Ec	R		
6	17:22	15:22	I	Tr	I	E	
	18:31	16:31	I	Sh	I	E	
	19:31	17:31	I	Tr	E		
	20:40	18:40	I	Sh	E		
7	17:51	15:51	I	Ec	R	E	
	18:24	16:24	III	Tr	I	E	
	20:21	18:21	III	Tr	E		
	23:13	21:13	III	Sh	I		
8	01:01	23:01(p)	III	Sh	E		
10	00:13	22:13(p)	II	Tr	I		
	02:39	00:39	II	Sh	I	W	
	02:48	00:48	II	Tr	E	W	
11	03:26	01:26	I	Oc	D	W	
	19:15	17:15	II	Oc	D		
12	00:11	22:11(p)	II	Ec	R		
	00:45	22:45(p)	I	Tr	I		
	01:57	23:57(p)	I	Sh	I	W	
	02:55	00:55	I	Tr	E	W	
	21:54	19:54	I	Oc	D		
13	01:17	23:17(p)	I	Ec	R		
	18:32	16:32	II	Sh	E	E	
	19:13	17:13	I	Tr	I		
	20:26	18:26	I	Sh	I		
	21:23	19:23	I	Tr	E		
	22:35	20:35	I	Sh	E		
14	19:46	17:46	I	Ec	R		
	22:09	20:09	III	Tr	I		
15	00:08	22:08(p)	III	Tr	E		
	03:11	01:11	III	Sh	I	W	
	17:04	15:04	I	Sh	E	E	
17	02:44	00:44	II	Tr	I	W	
18	17:18	15:18	III	Ec	D	E	
	19:07	17:07	III	Ec	R	E	
	21:45	19:45	II	Oc	D		
19	02:37	00:37	I	Tr	I	W	
	02:45	00:45	II	Ec	R	W	
	23:47	21:47	I	Oc	D		
20	03:13	01:13	I	Ec	R	W	
	18:36	16:36	II	Sh	I	E	
	18:37	16:37	II	Tr	E	E	
	21:06	19:06	I	Tr	I		
	21:09	19:09	II	Sh	E		
	22:21	20:21	I	Sh	I		
	23:15	21:15	I	Tr	E		
21	00:30	22:30(p)	I	Sh	E		
	18:15	16:15	I	Oc	D	E	
	21:42	19:42	I	Ec	R		
22	01:58	23:58(p)	III	Tr	I	W	
	17:44	15:44	I	Tr	E	E	
	18:58	16:58	I	Sh	E	E	
25	18:06	16:06	III	Oc	R	E	
	21:17	19:17	III	Ec	D		
	23:07	21:07	III	Ec	R		
26	00:16	22:16(p)	II	Oc	D		
27	01:41	23:41(p)	I	Oc	D	W	
	18:36	16:36	II	Tr	I	E	
	21:12	19:12	II	Tr	E		
	21:13	19:13	II	Sh	I		
	22:59	20:59	I	Tr	I		
	23:46	21:46	II	Sh	E		
28	00:15	22:15(p)	I	Sh	I		
	01:09	23:09(p)	I	Tr	E	W	
	02:24	00:24	I	Sh	E	W	
	20:09	18:09	I	Oc	D		
	23:37	21:37	I	Ec	R		
29	17:28	15:28	I	Tr	I	E	
	18:37	16:37	II	Ec	R	E	
	18:44	16:44	I	Sh	I	E	
	19:37	17:37	I	Tr	E		
	20:53	18:53	I	Sh	E		
30	18:06	16:06	I	Ec	R	E	

August

1	19:58	17:58	III	Oc	D		
	22:04	20:04	III	Oc	R		
2	01:17	23:17(p)	III	Ec	D	W	
3	21:12	19:12	II	Tr	I		
	23:49	21:49	II	Tr	E		
	23:51	21:51	II	Sh	I		
4	00:53	22:53(p)	I	Tr	I	W	
	02:10	00:10	I	Sh	I	W	
	02:24	00:24	II	Sh	E	W	
	22:04	20:04	I	Oc	D		
5	01:32	23:32(p)	I	Ec	R	W	
	19:22	17:22	I	Tr	I		
	20:39	18:39	I	Sh	I		
	21:12	19:12	II	Ec	R		
	21:32	19:32	I	Tr	E		
	22:48	20:48	I	Sh	E		
6	20:01	18:01	I	Ec	R		
7	17:16	15:16	I	Sh	E	E	
8	23:58	21:58	III	Oc	D	W	
9	02:06	00:06	III	Oc	R	W	
10	23:51	21:51	II	Tr	I	W	
12	00:00	22:00(p)	I	Oc	D	W	
	18:44	16:44	II	Oc	D	E	
	19:07	17:07	III	Sh	I	E	
	20:56	18:56	III	Sh	E		
	21:18	19:18	I	Tr	I		
	22:33	20:33	I	Sh	I		
	23:28	21:28	I	Tr	E		
	23:47	21:47	II	Ec	R	W	
13	00:42	22:42(p)	I	Sh	E	W	
	18:29	16:29	I	Oc	D	E	
	21:56	19:56	I	Ec	R		
14	17:57	15:57	I	Tr	E	E	
	18:20	16:20	II	Sh	E	E	
	19:11	17:11	I	Sh	E	E	
19	17:57	15:57	III	Tr	I	E	
	20:05	18:05	III	Tr	E		
	21:22	19:22	II	Oc	D		
	23:07	21:07	III	Sh	I		
	23:14	21:14	I	Tr	I	W	
20	00:28	22:28(p)	I	Sh	I	W	
	00:55	22:55(p)	III	Sh	E	W	
	01:24	23:24(p)	I	Tr	E	W	
	20:27	18:27	I	Oc	D		
	23:52	21:52	I	Ec	R	W	
21	17:43	15:43	I	Tr	I	E	
	18:24	16:24	II	Sh	I	E	
	18:29	16:29	II	Tr	E	E	
	18:57	16:57	I	Sh	I	E	
	19:53	17:53	I	Tr	E		
	20:58	18:58	II	Sh	E		
	21:06	19:06	I	Sh	E		
22	18:20	16:20	I	Ec	R	E	
26	22:06	20:06	III	Tr	I		
27	00:01	22:01(p)	II	Oc	D	W	
	00:15	22:15(p)	III	Tr	E	W	
	01:11	23:11(p)	I	Tr	I	W	
	22:24	20:24	I	Oc	D		
28	18:35	16:35	II	Tr	I	E	
	19:40	17:40	I	Tr	I		
	20:51	18:51	I	Sh	I		
	21:02	19:02	II	Sh	I		
	21:12	19:12	II	Tr	E		
	21:51	19:51	I	Tr	E		
	23:00	21:00	I	Sh	E	W	
	23:35	21:35	II	Sh	E	W	
29	20:16	18:16	I	Ec	R		
30	17:29	15:29	I	Sh	E	E	
	18:13	16:13	II	Ec	R	E	
	19:03	17:03	III	Ec	R	E	

September

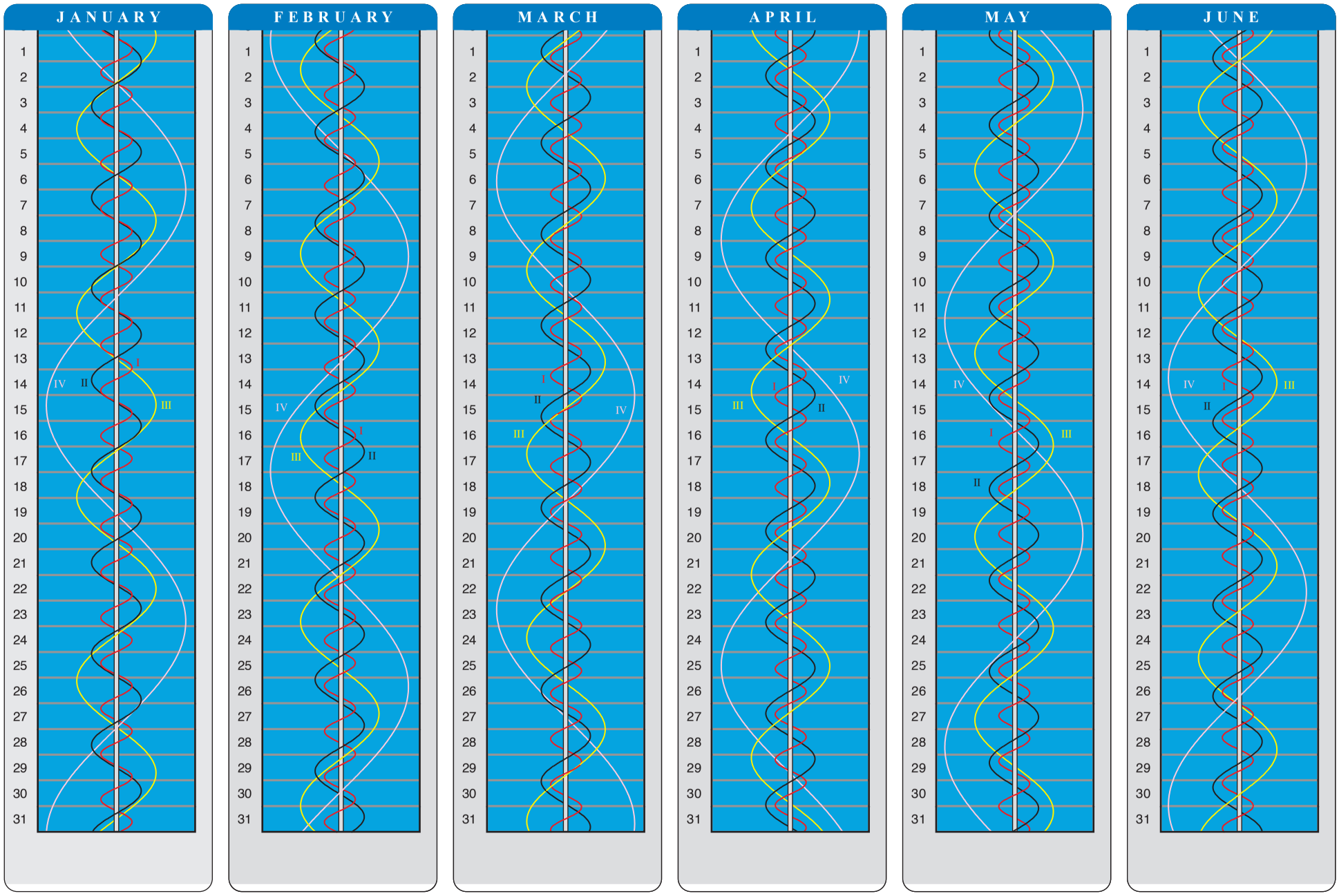
4	00:23	22:23(p)	I	Oc	D	W	
	21:20	19:20	II	Tr	I		
	21:38	19:38	I	Tr	I		
	22:46	20:46	I	Sh	I	W	
	23:40	21:40	II	Sh	I	W	
	23:49	21:49	I	Tr	E	W	
	23:57	21:57	II	Tr	E	W	
5	18:53	16:53	I	Oc	D	E	
	22:11	20:11	I	Ec	R		
6	18:18	16:18	I	Tr	E	E	
	18:45	16:45	III	Oc	R	E	
	19:23	17:23	I	Sh	E	E	
	20:47	18:47	II	Ec	R		
	21:14	19:14	III	Ec	D		
	23:04	21:04	III	Ec	R	W	
11	23:37	21:37	I	Tr	I	W	
12	00:06	22:06(p)	II	Tr	I	W	
	20:52	18:52	I	Oc	D		
13	00:06	22:06(p)	I	Ec	R	W	
	18:07	16:07	I	Tr	I	E	
	18:46	16:46	II	Oc	D	E	
	19:09	17:09	I	Sh	I	E	
	20:17	18:17	I	Tr	E		
	20:51	18:51	III	Oc	D		
	21:18	19:18	I	Sh	E		
	23:02	21:02	III	Oc	R	W	
	23:22	21:22	II	Ec	R	W	
14	18:35	16:35	I	Ec	R	E	
15	18:10	16:10	II	Sh	E	E	
19	22:52	20:52	I	Oc	D	W	
20	20:06	18:06	I	Tr	I		
	21:03	19:03	I	Sh	I		
	21:30	19:30	II	Oc	D	W	
	22:16	20:16	I	Tr	E	W	
	23:13	21:13	I	Sh	E	W	
21	20:30	18:30	I	Ec	R		
22	17:41	15:41	I	Sh	E	E	
	18:14	16:14	II	Sh	I	E	
	18:54	16:54	II	Tr	E	E	
	20:47	18:47	II	Sh	E		
24	19:00	17:00	III	Sh	I	E	
	20:50	18:50	III	Sh	E		
27	22:05	20:05	I	Tr	I	W	
	22:58	20:58	I	Sh	I	W	
28	19:22	17:22	I	Oc	D	E	
	22:25	20:25	I	Ec	R	W	
29	18:46	16:46	I	Tr	E	E	
	19:06	17:06	II	Tr	I	E	
	19:36	17:36	I	Sh	E	E	
	20:51	18:51	II	Sh	I		
	21:43	19:43	II	Tr	E	W	
	23:24	21:24	II	Sh	E	W	

October

1	17:48	15:48	II	Ec	R	E	
	19:31	17:31	III	Tr	I	E	
	21:40	19:40	III	Tr	E	W	
	23:00	21:00	III	Sh	I	W	
5	21:23	19:23	I	Oc	D	W	
6	18:36	16:36	I	Tr	I	E	
	19:21	17:21	I	Sh	I	E	
	20:46	18:46	I	Tr	E	W	
	21:30	19:30	I	Sh	E	W	
	21:55	19:55	II	Tr	I	W	
7	18:49	16:49	I	Ec	R	E	
8	20:23	18:23	II	Ec	R		
12	19:00	17:00	III	Ec	R	E	
13	20:36	18:36	I	Tr	I	W	
	21:15	19:15	I	Sh	I	W	
	22:46	20:46	I	Tr	E	W	
14	17:55	15:55	I	Oc	D	E	
	20:44	18:44	I	Ec	R	W	
15	17:53	15:53	I	Sh	E	E	
	19:11	17:11	II	Oc	D	E	
17	17:56	15:56	II	Sh	E	E	
19	18:44	16:44	III	Oc	D	E	
	20:53	18:53	III	Oc	R	W	
	21:07	19:07	III	Ec	D	W	
21	19:56	17:56	I	Oc	D	E	
22	19:17	17:17	I	Tr	E	E	
	19:47	17:47	I	Sh	E	E	
	21:58	19:58	II	Oc	D	W	
24	18:00	16:00	II	Sh	I	E	
	19:36	17:36	II	Tr	E	E	
	20:33	18:33	II	Sh	E	W	
28	21:58	19:58	I	Oc	D	W	
29	19:08	17:08	I	Tr	I	E	
	19:32	17:32	I	Sh	I	E	
	21:18	19:18	I	Tr	E	W	
	21:42	19:42	I	Sh	E	W	

December

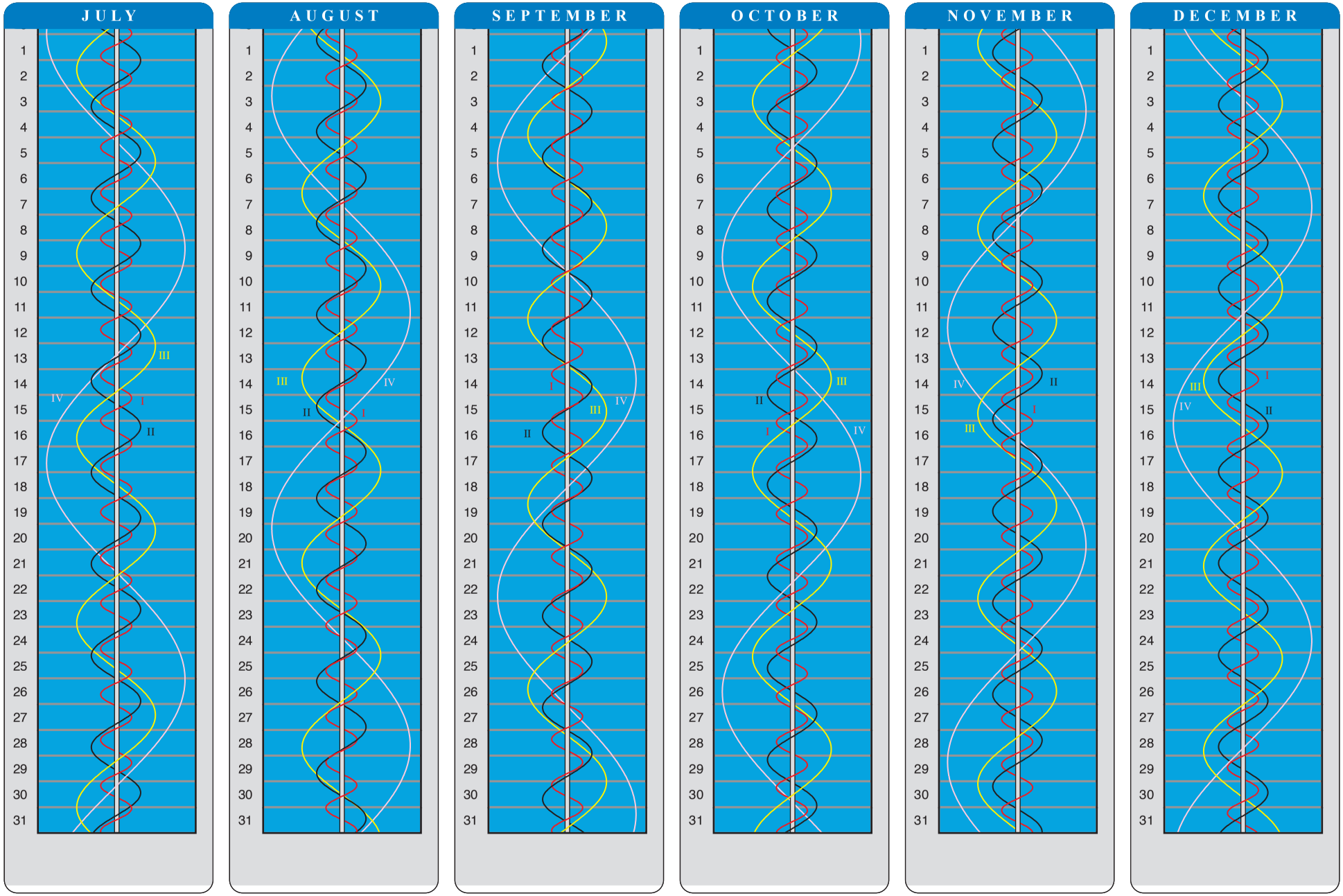
15	06:20	04:20	II	Ec	D	W	
16	04:55	02:55	III	Ec	D		
17	04:00	02:00	II	Sh	E	E	
	04:51	02:51	II	Tr	E		
19	06:11	04:11	I	Ec	D	W	
20	03:18	01:18	I	Sh	I	E	
	03:46	01:46	I	Tr	I	E	
	05:28	03:28	I	Sh	E	W	
	05:57	03:57	I	Tr	E	W	
21	03:19	01:19	I	Oc	R	E	
24	04:03	02:03	II	Sh	I	E	
	05:06	03:06	II	Tr	I		
	06:35	04:35	II	Sh	E	W	
27	02:58	00:58	III	Tr	E	E	
	05:12	03:12	I	Sh	I		
	05:46	03:46	I	Tr	I	W	
28	05:19	03:19	I	Oc	R	W	
31	06:37	04:37	II	Sh	I	W	



JUPITER'S MOONS

Jupiter is like a miniature Solar System with many moons orbiting the planet. As seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing in front of or behind the planet. The diagrams here show the patterns the four major moons of Jupiter make as they move from side-to-side. Each complete period represents one orbit of the satellite. Each horizontal grey date line

represents midnight; the top edge of the line is midnight EST (14hr UT), the bottom edge of the line is midnight WST (16hr UT). The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times (pp. 111–13). The same can be done with the occultation times, that is when the line disappears behind Jupiter. Satellite I is Io, II is Europa, III is Ganymede and IV is Callisto.



JUPITER

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

POSITION

0hrs UT Epoch 2000.0

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney		RA	DEC
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h m s	Set
Jan 7	01:13	14:44	00:57	14:05	01:01	14:32	02:15	14:45	00:54	14:54	01:13	14:53	01:19	14:40	00:55	14:22	14 48 09	- 15 01 43
14	00:49	14:21	00:33	13:42	00:36	14:10	01:51	14:22	00:30	14:32	00:48	14:31	00:55	14:17	00:30	13:59	14 52 08	- 15 18 29
21	00:24	13:58	00:08	13:19	00:12	13:47	01:27	13:58	00:05	14:09	00:24	14:08	00:30	13:54	00:06	13:36	14 55 44	- 15 33 08
28	23:56	13:34	23:40	12:55	23:43	13:23	01:02	13:34	23:36	13:45	23:55	13:44	00:05	13:30	23:37	13:12	14 58 54	- 15 45 34
Feb 4	23:30	13:10	23:15	12:30	23:18	12:58	00:37	13:09	23:10	13:21	23:30	13:20	23:36	13:06	23:12	12:48	15 01 34	- 15 55 41
11	23:04	12:45	22:49	12:05	22:52	12:33	00:12	12:44	22:44	12:56	23:04	12:55	23:10	12:41	22:46	12:23	15 03 43	- 16 03 26
18	22:38	12:19	22:23	11:40	22:26	12:08	23:42	12:18	22:18	12:31	22:37	12:29	22:44	12:15	22:20	11:57	15 05 18	- 16 08 45
25	22:12	11:53	21:56	11:13	21:59	11:41	23:16	11:52	21:51	12:04	22:11	12:03	22:17	11:48	21:53	11:31	15 06 18	- 16 11 37
Mar 4	21:44	11:26	21:29	10:46	21:32	11:14	22:48	11:24	21:24	11:37	21:44	11:36	21:50	11:21	21:26	11:03	15 06 42	- 16 11 59
11	21:17	10:58	21:01	10:18	21:04	10:46	22:21	10:57	20:56	11:09	21:16	11:08	21:23	10:53	20:58	10:36	15 06 29	- 16 09 52
18	20:49	10:29	20:33	09:50	20:36	10:18	21:52	10:28	20:28	10:41	20:48	10:39	20:54	10:25	20:30	10:07	15 05 39	- 16 05 20
25	20:20	10:00	20:04	09:20	20:07	09:49	21:23	09:59	20:00	10:11	20:19	10:10	20:26	09:56	20:01	09:38	15 04 13	- 15 58 27
Apr 1	19:51	09:30	19:35	08:51	19:38	09:19	20:54	09:30	19:31	09:41	19:50	09:40	19:57	09:26	19:32	09:08	15 02 15	- 15 49 21
8	19:21	08:59	19:06	08:20	19:09	08:48	20:24	08:59	19:02	09:11	19:21	09:09	19:27	08:55	19:03	08:37	14 59 46	- 15 38 16
15	18:52	08:28	18:36	07:49	18:39	08:17	19:54	08:29	18:32	08:39	18:51	08:38	18:57	08:24	18:33	08:06	14 56 53	- 15 25 30
22	18:22	07:57	18:06	07:18	18:09	07:46	19:24	07:58	18:02	08:08	18:21	08:06	18:27	07:53	18:03	07:35	14 53 40	- 15 11 24
29	17:52	07:25	17:35	06:47	17:39	07:14	18:53	07:27	17:32	07:36	17:51	07:35	17:57	07:21	17:33	07:03	14 50 15	- 14 56 24
May 6	17:21	06:54	17:05	06:15	17:09	06:42	18:22	06:55	17:02	07:04	17:21	07:03	17:27	06:50	17:02	06:31	14 46 43	- 14 40 59
13	16:51	06:22	16:34	05:43	16:38	06:10	17:51	06:24	16:33	06:32	16:51	06:31	16:56	06:18	16:32	06:00	14 43 13	- 14 25 44
20	16:21	05:50	16:04	05:12	16:08	05:39	17:21	05:53	16:03	06:00	16:21	05:59	16:26	05:46	16:02	05:28	14 39 51	- 14 11 09
27	15:51	05:19	15:34	04:41	15:38	05:07	16:50	05:22	15:33	05:28	15:51	05:28	15:56	05:15	15:32	04:57	14 36 44	- 13 57 45
Jun 3	15:21	04:48	15:04	04:10	15:09	04:36	16:20	04:52	15:03	04:57	15:21	04:57	15:26	04:44	15:02	04:26	14 33 58	- 13 46 02
10	14:52	04:18	14:35	03:40	14:39	04:06	15:50	04:22	14:34	04:27	14:52	04:26	14:57	04:14	14:33	03:56	14 31 37	- 13 36 25
17	14:23	03:48	14:05	03:10	14:10	03:36	15:21	03:52	14:05	03:57	14:23	03:57	14:28	03:44	14:04	03:26	14 29 46	- 13 29 12
24	13:54	03:19	13:37	02:41	13:42	03:07	14:52	03:23	13:37	03:27	13:54	03:28	13:59	03:15	13:35	02:57	14 28 26	- 13 24 36
Jul 1	13:26	02:50	13:09	02:13	13:14	02:39	14:24	02:55	13:09	02:59	13:26	02:59	13:31	02:47	13:07	02:28	14 27 41	- 13 22 48
8	12:58	02:23	12:41	01:45	12:46	02:11	13:57	02:27	12:41	02:31	12:58	02:31	13:03	02:19	12:39	02:01	14 27 29	- 13 23 51
15	12:31	01:56	12:14	01:18	12:19	01:44	13:29	02:00	12:14	02:04	12:31	02:05	12:36	01:52	12:12	01:34	14 27 52	- 13 27 41
22	12:04	01:29	11:47	00:52	11:52	01:18	13:03	01:34	11:47	01:38	12:04	01:38	12:09	01:26	11:45	01:07	14 28 49	- 13 34 15
29	11:38	01:04	11:20	00:26	11:25	00:52	12:37	01:08	11:20	01:13	11:38	01:13	11:43	01:00	11:19	00:42	14 30 19	- 13 43 25
Aug 5	11:12	00:39	10:54	23:57	10:59	00:27	12:11	00:42	10:54	00:48	11:11	00:48	11:17	00:35	10:53	00:17	14 32 20	- 13 55 00
12	10:46	00:14	10:29	23:33	10:33	00:00	11:46	00:18	10:28	00:24	10:46	00:24	10:51	00:11	10:27	23:49	14 34 52	- 14 08 48
19	10:21	23:47	10:04	23:09	10:08	23:36	11:21	23:50	10:02	23:57	10:20	23:57	10:26	23:44	10:02	23:25	14 37 51	- 14 24 35
26	09:56	23:24	09:39	22:46	09:43	23:13	10:56	23:26	09:37	23:34	09:55	23:33	10:01	23:20	09:37	23:02	14 41 17	- 14 42 09
Sep 2	09:31	23:01	09:15	22:23	09:18	22:50	10:32	23:03	09:12	23:12	09:30	23:11	09:36	22:58	09:12	22:39	14 45 08	- 15 01 15
9	09:07	22:39	08:51	22:00	08:54	22:28	10:09	22:40	08:47	22:50	09:06	22:49	09:12	22:35	08:48	22:17	14 49 21	- 15 21 38
16	08:42	22:17	08:27	21:38	08:30	22:06	09:45	22:17	08:23	22:29	08:42	22:27	08:48	22:13	08:24	21:55	14 53 55	- 15 43 03
23	08:19	21:56	08:03	21:16	08:06	21:44	09:22	21:55	07:58	22:07	08:18	22:06	08:25	21:52	08:00	21:34	14 58 48	- 16 05 17
30	07:55	21:35	07:40	20:55	07:42	21:23	09:00	21:33	07:34	21:47	07:54	21:45	08:01	21:30	07:36	21:12	15 03 59	- 16 28 08
Oct 7	07:32	21:14	07:17	20:33	07:19	21:02	08:37	21:11	07:11	21:26	07:31	21:24	07:38	21:09	07:13	20:51	15 09 25	- 16 51 20
14	07:09	20:53	06:54	20:12	06:56	20:42	08:15	20:50	06:47	21:06	07:07	21:03	07:15	20:48	06:50	20:31	15 15 05	- 17 14 41
21	06:46	20:33	06:32	19:52	06:33	20:21	07:53	20:28	06:24	20:46	06:44	20:43	06:52	20:28	06:27	20:10	15 20 57	- 17 38 00
28	06:23	20:12	06:09	19:31	06:10	20:01	07:31	20:07	06:01	20:26	06:21	20:23	06:30	20:07	06:05	19:50	15 26 59	- 18 01 06
Nov 4	06:00	19:52	05:47	19:11	05:48	19:41	07:09	19:46	05:38	20:06	05:59	20:03	06:07	19:47	05:42	19:30	15 33 10	- 18 23 47
11	05:38	19:32	05:25	18:50	05:25	19:21	06:48	19:25	05:15	19:47	05:36	19:43	05:45	19:27	05:20	19:10	15 39 28	- 18 45 54
18	05:16	19:12	05:03	18:30	05:03	19:01	06:26	19:04	04:52	19:27	05:14	19:23	05:23	19:07	04:57	18:50	15 45 51	- 19 07 18
25	04:53	18:52	04:41	18:10	04:41	18:41	06:05	18:44	04:29	19:08	04:51	19:03	05:01	18:47	04:35	18:29	15 52 17	- 19 27 51
Dec 2	04:31	18:32	04:19	17:49	04:18	18:21	05:43	18:23	04:07	18:48	04:29	18:43	04:39	18:27	04:13	18:09	15 58 45	- 19 47 25
9	04:09	18:12	03:57	17:29	03:56	18:01	05:22	18:02	03:44	18:28	04:07	18:23	04:16	18:06	03:51	17:49	16 05 11	- 20 05 55
16	03:47	17:52	03:35	17:08	03:34	17:41	05:00	17:41	03:22	18:08	03:45	18:03	03:55	17:46	03:29	17:29	16 11 35	- 20 23 15
23	03:25	17:31	03:13	16:48	03:12	17:20	04:39	17:20	02:59	17:48	03:22	17:43	03:32	17:26	03:07	17:09	16 17 54	- 20 39 22
30	03:03	17:11	02:51	16:27	02:50	17:00	04:17	16:59	02:37	17:28	03:00	17:23	03:10	17:05	02:45	16:48	16 24 06	- 20 54 12

JUPITER – LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (° at 0hr UT)													
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	070.7	284.0	025.9	243.9	305.1	163.2	220.4	072.0	281.1	331.2	178.6	228.8	1
2	228.5	081.8	183.9	042.0	103.2	321.2	018.2	229.8	078.8	128.9	336.3	026.5	2
3	026.3	239.7	341.8	200.0	261.2	119.1	176.1	027.5	236.5	286.5	133.9	184.2	3
4	184.1	037.6	139.8	358.0	059.2	277.1	333.9	185.3	034.2	084.2	291.6	341.9	4
5	341.9	195.5	297.8	156.1	217.3	075.0	131.7	343.0	191.9	241.8	089.3	139.6	5
6	139.8	353.4	095.8	314.1	015.3	233.0	289.6	140.7	349.5	039.5	246.9	297.3	6
7	297.6	151.3	253.8	112.2	173.3	030.9	087.4	298.5	147.2	197.1	044.6	095.0	7
8	095.4	309.2	051.7	270.2	331.3	188.8	245.2	096.2	304.9	354.8	202.3	252.7	8
9	253.2	107.2	209.7	068.2	129.4	346.8	043.0	253.9	102.6	152.5	359.9	050.4	9
10	051.1	265.1	007.7	226.3	287.4	144.7	200.9	051.7	260.2	310.1	157.6	208.1	10
11	208.9	063.0	165.7	024.3	085.4	302.6	358.7	209.4	057.9	107.8	315.3	005.8	11
12	006.7	220.9	323.7	182.4	243.4	100.6	156.5	007.1	215.6	265.4	112.9	163.5	12
13	164.6	018.8	121.7	340.4	041.4	258.5	314.3	164.8	013.3	063.1	270.6	321.2	13
14	322.4	176.7	279.7	138.4	199.4	056.4	112.1	322.5	170.9	220.7	068.3	118.9	14
15	120.2	334.7	077.7	296.5	357.5	214.3	269.9	120.3	328.6	018.4	225.9	276.6	15
16	278.1	132.6	235.7	094.5	155.5	012.2	067.7	278.0	126.3	176.1	023.6	074.3	16
17	075.9	290.5	033.7	252.6	313.5	170.1	225.5	075.7	283.9	333.7	181.3	232.1	17
18	233.8	088.5	191.7	050.6	111.5	328.0	023.3	233.4	081.6	131.4	339.0	029.8	18
19	031.6	246.4	349.7	208.6	269.5	125.9	181.1	031.1	239.3	289.0	136.6	187.5	19
20	189.5	044.3	147.7	006.7	067.5	283.8	338.9	188.8	036.9	086.7	294.3	345.2	20
21	347.3	202.3	305.7	164.7	225.5	081.7	136.6	346.5	194.6	244.3	092.0	142.9	21
22	145.2	000.2	103.7	322.8	023.5	239.6	294.4	144.2	352.3	042.0	249.7	300.6	22
23	303.1	158.2	261.7	120.8	181.4	037.5	092.2	301.9	149.9	199.7	047.4	098.4	23
24	100.9	316.1	059.8	278.9	339.4	195.3	250.0	099.6	307.6	357.3	205.0	256.1	24
25	258.8	114.1	217.8	076.9	137.4	353.2	047.7	257.3	105.2	155.0	002.7	053.8	25
26	056.7	272.0	015.8	234.9	295.4	151.1	205.5	055.0	262.9	312.6	160.4	211.5	26
27	214.5	070.0	173.8	033.0	093.4	308.9	003.3	212.7	060.6	110.3	318.1	009.3	27
28	012.4	227.9	331.8	191.0	251.4	106.8	161.0	010.4	218.2	268.0	115.8	167.0	28
29	170.3		129.9	349.1	049.3	264.7	318.8	168.1	015.9	065.6	273.5	324.7	29
30	328.2		287.9	147.1	207.3	062.5	116.5	325.8	173.5	223.3	071.2	122.5	30
31	126.1		085.9		005.3		274.3	123.5		020.9		280.2	31

SYSTEM II (° at 0hr UT)													
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Date
1	246.0	222.7	111.0	092.5	284.8	266.3	094.6	069.8	042.4	223.5	194.4	015.7	1
2	036.2	013.0	261.3	242.9	075.2	056.7	244.8	219.9	192.4	013.6	344.4	165.8	2
3	186.4	163.2	051.7	033.3	225.6	207.0	035.0	010.0	342.5	163.6	134.5	315.9	3
4	336.5	313.5	202.0	183.7	016.0	357.3	185.2	160.1	132.5	313.6	284.5	105.9	4
5	126.7	103.8	352.4	334.1	166.4	147.6	335.4	310.2	282.6	103.6	074.5	256.0	5
6	276.9	254.0	142.7	124.5	316.8	297.9	125.6	100.3	072.6	253.7	224.6	046.1	6
7	067.1	044.3	293.1	274.9	107.2	088.3	275.8	250.4	222.7	043.7	014.6	196.1	7
8	217.3	194.6	083.4	065.3	257.6	238.6	066.0	040.5	012.7	193.7	164.7	346.2	8
9	007.5	344.9	233.8	215.7	048.0	028.9	216.2	190.6	162.7	343.8	314.7	136.3	9
10	157.7	135.1	024.1	006.1	198.4	179.2	006.4	340.7	312.8	133.8	104.7	286.3	10
11	307.9	285.4	174.5	156.6	348.7	329.5	156.6	130.8	102.8	283.8	254.8	076.4	11
12	098.1	075.7	324.8	307.0	139.1	119.8	306.8	280.9	252.9	073.8	044.8	226.5	12
13	248.3	226.0	115.2	097.4	289.5	270.0	097.0	071.0	042.9	223.9	194.9	016.6	13
14	038.5	016.3	265.6	247.8	079.9	060.3	247.1	221.1	193.0	013.9	344.9	166.6	14
15	188.7	166.6	055.9	038.2	230.3	210.6	037.3	011.2	343.0	163.9	134.9	316.7	15
16	338.9	316.9	206.3	188.6	020.7	000.9	187.5	161.3	133.0	313.9	285.0	106.8	16
17	129.2	107.2	356.7	339.0	171.0	151.2	337.7	311.3	283.1	104.0	075.0	256.9	17
18	279.4	257.5	147.1	129.4	321.4	301.4	127.8	101.4	073.1	254.0	225.1	047.0	18
19	069.6	047.8	297.4	279.9	111.8	091.7	278.0	251.5	223.1	044.0	015.1	197.1	19
20	219.8	198.1	087.8	070.3	262.1	242.0	068.1	041.6	013.2	194.1	165.2	347.1	20
21	010.0	348.4	238.2	220.7	052.5	032.2	218.3	191.7	163.2	344.1	315.2	137.2	21
22	160.3	138.7	028.6	011.1	202.9	182.5	008.4	341.7	313.3	134.1	105.3	287.3	22
23	310.5	289.1	179.0	161.5	353.2	332.7	158.6	131.8	103.3	284.1	255.3	077.4	23
24	100.7	079.4	329.3	311.9	143.6	123.0	308.7	281.9	253.3	074.2	045.4	227.5	24
25	251.0	229.7	119.7	102.3	293.9	273.2	098.9	071.9	043.3	224.2	195.4	017.6	25
26	041.2	020.0	270.1	252.7	084.3	063.5	249.0	222.0	193.4	014.2	345.5	167.7	26
27	191.5	170.3	060.5	043.1	234.6	213.7	039.1	012.1	343.4	164.3	135.5	317.8	27
28	341.7	320.7	210.9	193.5	025.0	003.9	189.3	162.1	133.4	314.3	285.6	107.9	28
29	132.0		001.3	344.0	175.3	154.2	339.4	312.2	283.5	104.3	075.6	258.0	29
30	282.2		151.7	134.4	325.7	304.4	129.5	102.2	073.5	254.3	225.7	048.1	30
31	072.5		302.1		116.0		279.6	252.3		044.4		198.2	31

Jupiter is a gas giant and we can only view the upper atmospheric features. Only a small telescope (even a 60mm instrument) is required to view the equatorial belts and the Great Red Spot. When seeing is good, numerous breaks can be glimpsed in the bands, as well as many minor spots. There is no single correct rotation period for the features of Jupiter. The speed of movement of any feature on the 'surface' depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs often measure the time a feature crosses the central meridian of the planet.

The longitude can be worked out from the tables here. All the times on the main tables are calculated for 0hr UT of date. You will need to add multiple hours and minutes from the small 'Increase in Longitude' tables below. For example, the longitude of central meridian for Jupiter (System I) for June 27 at 2:20am EST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on June 26. From the table, the longitude on June 26 is 151.1°. To this add an adjustment for the 16 hours, which is 225.3°, and finally for the 20 minutes add 12.2°. These add up to 388.6°; less 360° gives a final answer of 28.6°.

Finding the Great Red Spot (GRS)

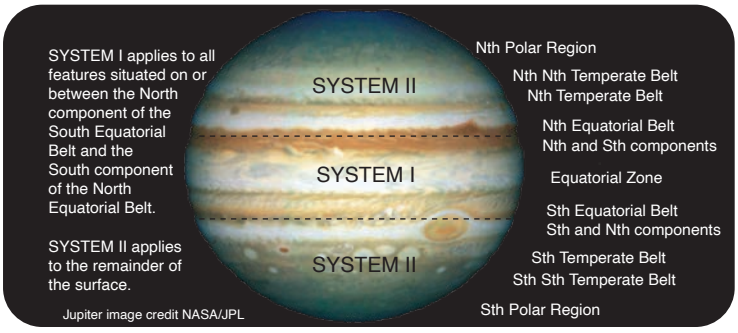
At the time of publication the GRS was located at 103° longitude using System II (it slowly drifts over the years e.g., at the beginning of 2004 its longitude was 91°). For all features visible on Jupiter they are best observed from about one hour before crossing the central meridian to one hour after. Based on System II this results in plus or minus about 36° (see correction table below) or in the case of the GRS about 67° to 139°.

For example calculating the System II value for March 29 at 10:40pm EST, gives a value of 100.6°. The GRS should be just approaching a transit. The GRS in recent years has lost a lot of its red colouration and now looks more pale orange or tan and can be difficult to observe.

The longitude of the GRS was obtained via links from the web site below, as calculated by John W. McAnally of the Association of Lunar and Planetary Observers (ALPO). Updates for its longitude and predicted times (in UT) for the GRS crossing the central meridian can be found at (http://ncastro.org/juptrans.html)

Increase In Longitude
SYSTEM I
Rotation: 9h 50m 30.003s

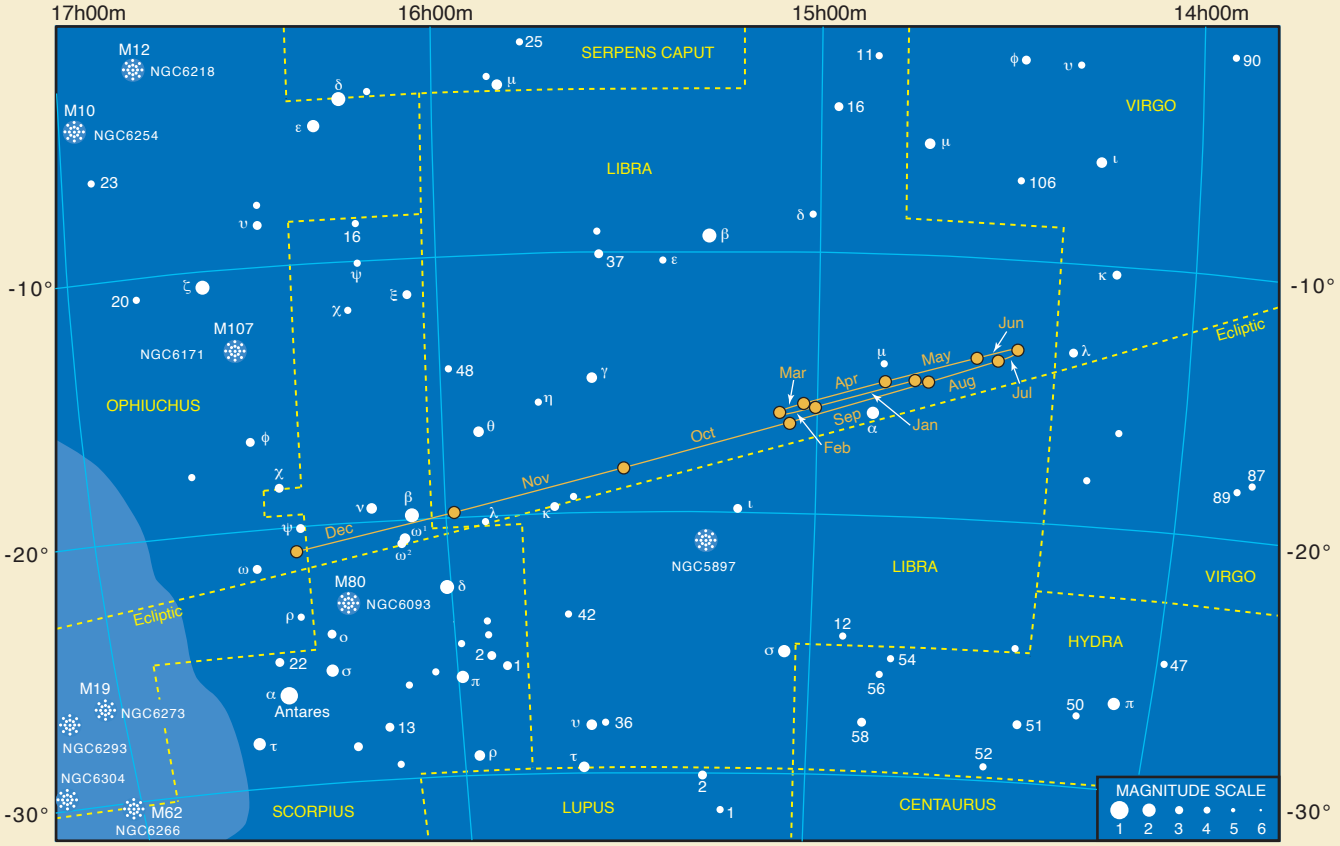
hr	deg°	hr	deg°	min	deg°
1	036.6	13	115.5	5	03.0
2	073.2	14	152.1	10	06.1
3	109.7	15	188.7	15	09.1
4	146.3	16	225.3	20	12.2
5	182.9	17	261.8	25	15.2
6	219.5	18	298.4	30	18.3
7	256.1	19	335.0	35	21.3
8	292.6	20	011.6	40	24.4
9	329.2	21	048.2	45	27.4
10	005.8	22	084.7	50	30.5
11	042.4	23	121.3	55	33.5
12	079.0	24	157.9	60	36.6



Increase In Longitude
SYSTEM II
Rotation: 9h 55m 40.062s

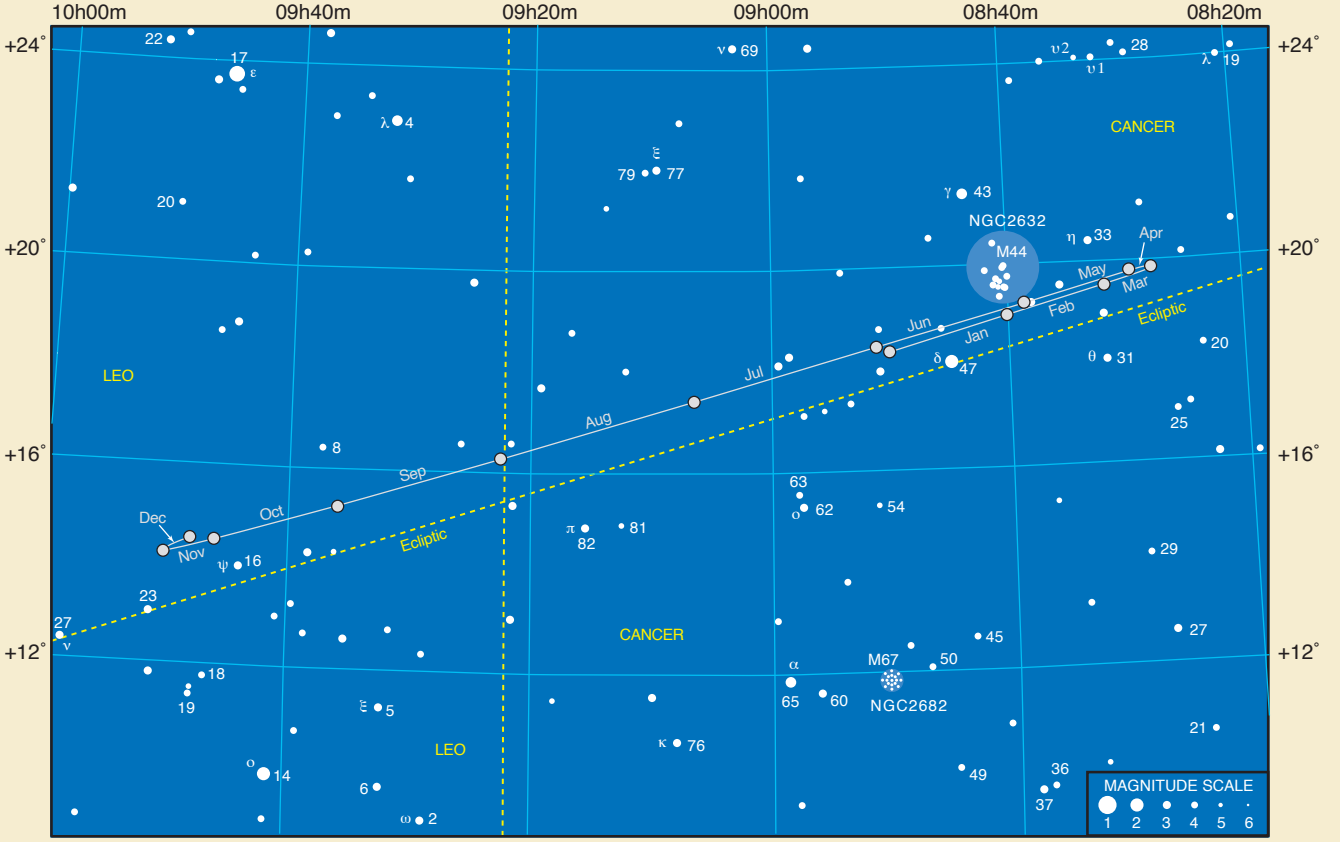
hr	deg°	hr	deg°	min	deg°
1	036.3	13	111.4	5	03.0
2	072.5	14	147.7	10	06.0
3	108.8	15	183.9	15	09.1
4	145.0	16	220.2	20	12.1
5	181.3	17	256.5	25	15.1
6	217.6	18	292.7	30	18.1
7	253.8	19	329.0	35	21.2
8	290.1	20	005.2	40	24.2
9	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

JUPITER FINDER CHART



Stationary 5th March, Opposition 5th May, Stationary 7th July, Conjunction 22nd November.

SATURN FINDER CHART



Opposition 28th January, Stationary 5th April, Conjunction 7th August, Stationary 7th December.

SATURN

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan 7	20:47	07:08	20:06	06:54	20:36	06:55	20:42	08:16	21:01	06:46	20:58	07:06	20:43	07:14	20:25	06:49
14	20:18	06:38	19:37	06:24	20:07	06:25	20:13	07:46	20:32	06:16	20:29	06:36	20:13	06:44	19:56	06:19
21	19:49	06:08	19:08	05:54	19:38	05:55	19:43	07:16	20:03	05:45	20:00	06:06	19:44	06:14	19:27	05:49
28	19:20	05:37	18:38	05:24	19:08	05:24	19:14	06:46	19:34	05:15	19:30	05:36	19:15	05:44	18:57	05:19
Feb 4	18:50	05:07	18:09	04:53	18:39	04:54	18:44	06:16	19:04	04:44	19:01	05:05	18:45	05:13	18:28	04:48
11	18:21	04:37	17:39	04:23	18:10	04:24	18:14	05:46	18:35	04:14	18:32	04:35	18:16	04:43	17:59	04:18
18	17:52	04:07	17:10	03:53	17:41	03:54	17:45	05:16	18:06	03:43	18:03	04:05	17:47	04:13	17:29	03:48
25	17:23	03:37	16:41	03:24	17:12	03:24	17:15	04:47	17:37	03:13	17:34	03:35	17:18	03:43	17:00	03:18
Mar 4	16:54	03:07	16:12	02:54	16:43	02:54	16:46	04:17	17:09	02:44	17:05	03:05	16:49	03:14	16:31	02:49
11	16:25	02:38	15:43	02:25	16:14	02:25	16:17	03:48	16:40	02:14	16:36	02:36	16:20	02:45	16:03	02:19
18	15:57	02:09	15:15	01:56	15:46	01:56	15:49	03:20	16:12	01:45	16:08	02:07	15:51	02:16	15:34	01:51
25	15:29	01:40	14:47	01:28	15:17	01:28	15:21	02:51	15:44	01:17	15:40	01:38	15:23	01:47	15:06	01:22
Apr 1	15:01	01:12	14:19	01:00	14:50	01:00	14:53	02:23	15:16	00:49	15:12	01:10	14:55	01:19	14:38	00:54
8	14:33	00:45	13:51	00:32	14:22	00:32	14:25	01:56	14:48	00:21	14:44	00:43	14:28	00:52	14:11	00:26
15	14:06	00:18	13:24	00:05	13:55	00:05	13:58	01:29	14:21	23:50	14:17	00:16	14:01	00:25	13:44	23:55
22	13:39	23:47	12:57	23:34	13:28	23:34	13:31	01:02	13:54	23:23	13:50	23:45	13:34	23:54	13:17	23:29
29	13:12	23:21	12:30	23:08	13:01	23:08	13:05	00:35	13:27	22:57	13:23	23:19	13:07	23:28	12:50	23:02
May 6	12:46	22:55	12:04	22:42	12:35	22:42	12:38	00:09	13:01	22:31	12:57	22:53	12:41	23:02	12:23	22:37
13	12:20	22:29	11:38	22:16	12:09	22:17	12:12	23:40	12:34	22:06	12:31	22:28	12:15	22:36	11:57	22:11
20	11:54	22:04	11:12	21:51	11:43	21:51	11:47	23:14	12:08	21:41	12:05	22:02	11:49	22:11	11:31	21:46
27	11:28	21:39	10:46	21:26	11:17	21:27	11:21	22:49	11:43	21:16	11:39	21:38	11:23	21:46	11:06	21:21
Jun 3	11:03	21:15	10:21	21:02	10:51	21:02	10:56	22:24	11:17	20:52	11:13	21:13	10:58	21:22	10:40	20:56
10	10:37	20:51	09:56	20:37	10:26	20:38	10:31	22:00	10:51	20:28	10:48	20:49	10:32	20:57	10:15	20:32
17	10:12	20:27	09:31	20:13	10:01	20:14	10:06	21:35	10:26	20:04	10:23	20:25	10:07	20:33	09:50	20:08
24	09:47	20:03	09:06	19:49	09:36	19:50	09:42	21:11	10:01	19:41	09:58	20:01	09:42	20:09	09:25	19:44
Jul 1	09:22	19:39	08:41	19:25	09:11	19:26	09:17	20:47	09:35	19:17	09:33	19:38	09:17	19:46	09:00	19:21
8	08:57	19:16	08:16	19:01	08:46	19:03	08:53	20:23	09:10	18:54	09:08	19:14	08:53	19:22	08:35	18:57
15	08:33	18:52	07:52	18:38	08:21	18:40	08:29	19:59	08:45	18:31	08:43	18:51	08:28	18:59	08:10	18:34
22	08:08	18:29	07:27	18:14	07:56	18:16	08:04	19:35	08:20	18:08	08:18	18:28	08:03	18:35	07:45	18:10
29	07:43	18:06	07:03	17:51	07:32	17:53	07:40	19:12	07:55	17:45	07:53	18:05	07:38	18:12	07:21	17:47
Aug 5	07:18	17:43	06:38	17:28	07:07	17:30	07:16	18:48	07:30	17:22	07:28	17:42	07:14	17:49	06:56	17:24
12	06:54	17:20	06:14	17:04	06:42	17:07	06:52	18:24	07:05	16:59	07:03	17:19	06:49	17:26	06:31	17:01
19	06:29	16:56	05:49	16:41	06:17	16:44	06:28	18:00	06:40	16:36	06:39	16:56	06:25	17:02	06:07	16:38
26	06:04	16:33	05:25	16:18	05:53	16:21	06:03	17:37	06:15	16:13	06:14	16:32	06:00	16:39	05:42	16:14
Sep 2	05:39	16:10	05:00	15:54	05:28	15:57	05:39	17:13	05:50	15:50	05:49	16:09	05:35	16:16	05:17	15:51
9	05:14	15:47	04:35	15:30	05:03	15:34	05:15	16:49	05:25	15:27	05:24	15:46	05:10	15:52	04:52	15:28
16	04:49	15:23	04:10	15:07	04:38	15:10	04:50	16:25	05:00	15:04	04:59	15:22	04:45	15:28	04:27	15:04
23	04:24	14:59	03:45	14:43	04:13	14:47	04:25	16:01	04:34	14:40	04:33	14:59	04:20	15:05	04:02	14:40
30	03:59	14:35	03:20	14:19	03:47	14:23	04:01	15:36	04:09	14:17	04:08	14:35	03:55	14:41	03:37	14:16
Oct 7	03:33	14:11	02:55	13:54	03:22	13:58	03:36	15:12	03:43	13:53	03:43	14:11	03:30	14:16	03:11	13:52
14	03:08	13:47	02:30	13:30	02:56	13:34	03:10	14:47	03:17	13:28	03:17	13:46	03:04	13:52	02:46	13:28
21	02:42	13:22	02:04	13:05	02:31	13:09	02:45	14:22	02:51	13:04	02:51	13:22	02:38	13:27	02:20	13:03
28	02:16	12:57	01:38	12:40	02:05	12:44	02:19	13:56	02:25	12:39	02:25	12:57	02:13	13:02	01:54	12:38
Nov 4	01:50	12:31	01:12	12:14	01:39	12:19	01:54	13:31	01:59	12:14	01:59	12:31	01:46	12:36	01:28	12:12
11	01:24	12:06	00:46	11:48	01:12	11:53	01:27	13:05	01:32	11:48	01:33	12:06	01:20	12:11	01:02	11:47
18	00:57	11:39	00:19	11:22	00:46	11:27	01:01	12:38	01:06	11:22	01:06	11:39	00:54	11:44	00:35	11:20
25	00:30	11:13	23:49	10:55	00:19	11:00	00:34	12:12	00:39	10:55	00:39	11:13	00:27	11:18	00:08	10:54
Dec 2	23:59	10:46	23:21	10:28	23:48	10:33	00:07	11:44	00:12	10:28	00:12	10:46	23:56	10:51	23:37	10:27
9	23:32	10:18	22:54	10:01	23:20	10:06	23:36	11:17	23:40	10:01	23:41	10:18	23:28	10:23	23:10	09:59
16	23:04	09:50	22:26	09:33	22:53	09:38	23:08	10:49	23:13	09:33	23:13	09:50	23:00	09:55	22:42	09:31
23	22:36	09:22	21:58	09:05	22:25	09:09	22:40	10:21	22:45	09:04	22:45	09:22	22:33	09:27	22:14	09:03
30	22:08	08:53	21:30	08:36	21:56	08:40	22:11	09:52	22:17	08:35	22:17	08:53	22:04	08:58	21:46	08:34

POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
08 48 09	+ 18 30 46
08 46 02	+ 18 39 58
08 43 47	+ 18 49 31
08 41 28	+ 18 59 09
08 39 08	+ 19 08 37
08 36 52	+ 19 17 38
08 34 44	+ 19 25 59
08 32 47	+ 19 33 30
08 31 03	+ 19 40 02
08 29 37	+ 19 45 25
08 28 30	+ 19 49 36
08 27 43	+ 19 52 31
08 27 18	+ 19 54 08
08 27 14	+ 19 54 25
08 27 33	+ 19 53 25
08 28 14	+ 19 51 08
08 29 16	+ 19 47 37
08 30 38	+ 19 42 52
08 32 19	+ 19 36 57
08 34 18	+ 19 29 55
08 36 34	+ 19 21 48
08 39 04	+ 19 12 41
08 41 48	+ 19 02 36
08 44 43	+ 18 51 39
08 47 49	+ 18 39 51
08 51 04	+ 18 27 18
08 54 26	+ 18 14 05
08 57 53	+ 18 00 16
09 01 25	+ 17 45 56
09 05 00	+ 17 31 11
09 08 37	+ 17 16 06
09 12 13	+ 17 00 50
09 15 48	+ 16 45 26
09 19 20	+ 16 30 04
09 22 47	+ 16 14 51
09 26 09	+ 15 59 54
09 29 24	+ 15 45 22
09 32 30	+ 15 31 23
09 35 26	+ 15 18 07
09 38 11	+ 15 05 43
09 40 43	+ 14 54 19
09 43 00	+ 14 44 04
09 45 01	+ 14 35 08
09 46 45	+ 14 27 40
09 48 11	+ 14 21 45
09 49 18	+ 14 17 31
09 50 04	+ 14 15 04
09 50 29	+ 14 14 27
09 50 33	+ 14 15 41
09 50 15	+ 14 18 45
09 49 36	+ 14 23 36
09 48 38	+ 14 30 07

SATELLITES OF SATURN

These pages are designed to help you find the position of Saturn's major satellites.

Note, dates and times on these two pages are given in day/fractions in UT. You will need to convert your local time to this format first. Table 3 will help.

Rhea and Dione

Table 1 presents the times of the first greatest elongation to the east for each month. This location is the day 0 (zero) point on the Apparent Orbits diagram. The procedure is to work out how many orbits have elapsed since the first elongation of the month. Then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of Rhea for January 25 at 3am (EST).

1. Convert to UT as a fractional day.
   Jan 25 at 3am EST is 17hr UT on the 24th which is 24.708 UT.
2. Subtract the date of the greatest elongation east for Jan, i.e. 24.708 – 1.063 = 23.645.
3. Express this as the number of orbits by dividing by the period i.e. 23.645 / 4.521 = 5.230.
4. Discard the 5 completed orbits leaves 0.230 (i.e., it is a little under a quarter of the way around its orbit).
5. Multiply by the period, 0.230 X 4.521 = 1.040 days or 1 day 1.0 hr.
6. Looking at the orbital path for Rhea (see Apparent Orbit diagram), the satellite is north and a little east of Saturn – a little past (or west) of the 1d mark.

Table 1: Saturn Satellites – Time of Greatest Elongation East (dd.ddd UT)

Moon	Mimas	Enceladus	Tethys	Dione	Rhea
Magnitude [1]	12.800	11.800	10.200	10.4	9.600
Max Elong. [1]	0' 30"	0' 38"	0' 48"	1' 01"	1' 25"
Period (days) [2]	0.942	1.371	1.888	2.738	4.521
Month	**Elongation (d.ddd)**				
January	1.429	1.563	2.679	1.183	1.063
February	1.525	2.067	1.871	3.008	1.654
March	1.792	1.463	2.175	2.363	5.250
April	1.892	1.979	1.379	1.463	1.346
May	1.113	2.129	1.588	1.579	2.979
June	1.221	1.283	2.696	3.442	3.633
July	1.388	1.442	1.029	3.571	5.300
August	1.500	1.971	2.146	2.708	1.446
September	1.608	1.129	1.367	1.842	2.117
October	1.775	1.283	1.588	1.971	3.779
November	1.879	1.808	2.692	1.092	4.429
December	1.096	1.954	1.013	1.204	1.542

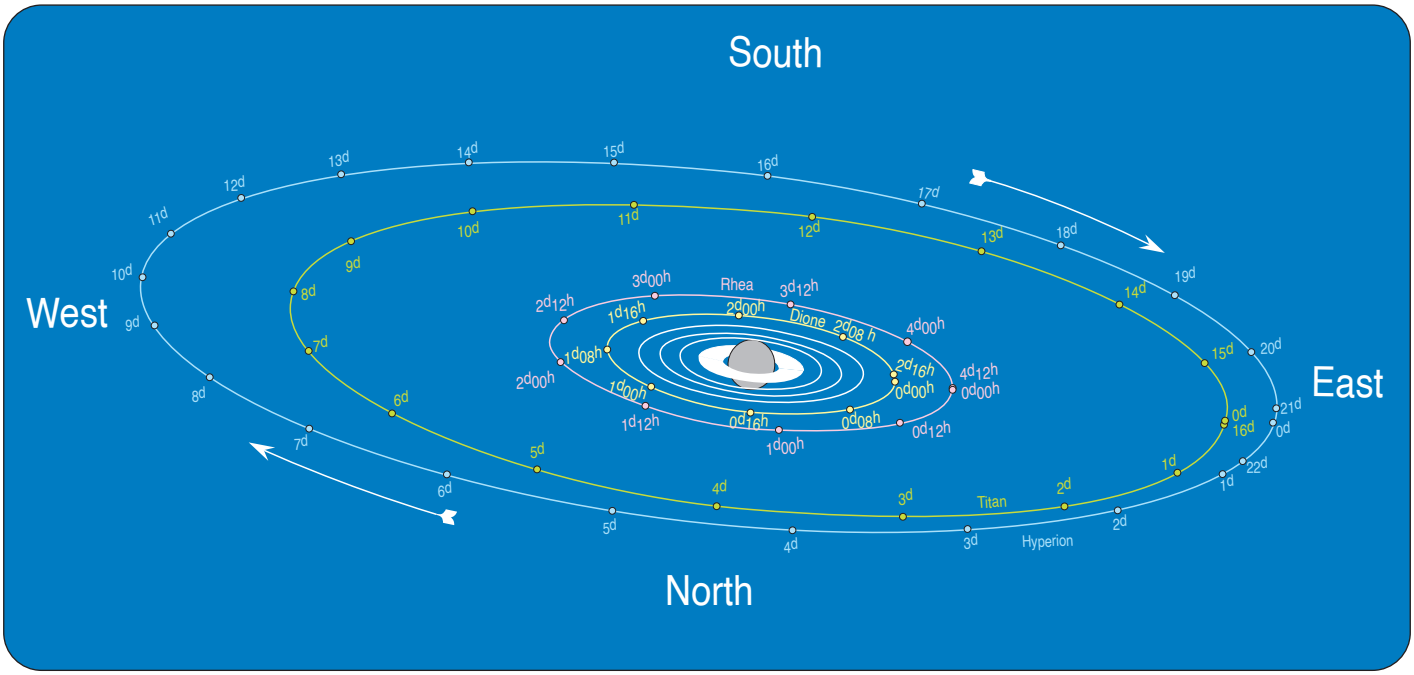
Notes 1. When at opposition
2. Mean Synodic Period

Mimas, Enceladus and Tethys

The procedure is similar to Rhea and Dione above with the times of the first greatest elongation east for each month also being listed in table 1. However, these inner moons are so close to Saturn that the orbits are represented on the diagram but it is difficult to put the day markers on and still have it readable. As above we calculate the fraction of the orbit and then estimate its position. Like the other major moons, these moons still orbit clockwise, so three quarters of an orbit (0.75) would place it south of Saturn.

An example. Estimate the position for Tethys for January 22 at 10pm EST (22.500 UT). 10.50 orbits have elapsed since its greatest elongation east on Jan 2.679 UT). Discarding the 10 orbits leaves 0.50. Tethys is half way around its orbit and is west of Saturn (western elongation).

APPARENT ORBITS OF SATURN'S SATELLITES



Apparent orbits of the satellites on January 27 UT. Only the inner satellites are shown.
The orbits of Iapetus and Phoebe are too large to show on the above diagram.

Titan and Hyperion

Because of their long periods, compared to the moons listed left, it is possible to list all of their greatest elongations for the year (see table 2). Therefore, all you need to do is work out the number of days that have elapsed since the most recent elongation and read this position directly off the diagram. For example on February 25 at 9pm EST (25.458 UT), Hyperion is 2.62 days past a greatest elongation east which puts it NE of Saturn.

Table 3
Converting Time in Australia to Universal Time (UT) *

EST	WST	Fraction of day (UT)
6pm	4pm	0.333
7pm	5pm	0.375
8pm	6pm	0.417
9pm	7pm	0.458
10pm	8pm	0.500
11pm	9pm	0.542
midnight	10pm	0.583
1am	11pm	0.625
2am	midnight	0.667
3am	1am	0.708
4am	2am	0.750
5am	3am	0.792
6am	4am	0.833
7am	5am	0.875
8am	6am	0.917

* After midnight it is still the previous day in UT, for example 1am (EST) on the 21st = 20.625 days UT

Table 2
Time of Greatest Elongation East (UT)

Moon	Titan	Hyperion
Magnitude [1]	8.4	14.4
Max. Elong. [1]	3' 17"	3' 59"
Period (days) [2]	15.971	21.317
	Elongation (d.ddd)	
January	13.871	11.517
	29.754	
February	14.638	1.667
		22.833
March	2.533	16.033
	18.446	
April	3.379	6.192
	19.329	27.417
May	5.308	18.692
	21.300	
June	6.308	8.933
	22.333	30.238
July	8.363	21.550
	24.396	
August	9.433	11.829
	25.471	
September	10.500	2.163
	26.525	23.475
October	12.538	14.742
	28.533	
November	13.517	5.063
	29.479	26.338
December	15.421	17.554
	31.346	

Notes 1. When at opposition
2. Mean Synodic Period

SATURN'S RINGS

Date	Major "	Minor "	U °	B °
Jan 1	45.6	14.1	3.7	-18.0
Jan 9	45.9	14.4	3.2	-18.3
Jan 17	46.1	14.6	2.6	-18.5
Jan 25	46.2	14.9	1.9	-18.8
Feb 2	46.2	15.0	1.3	-19.0
Feb 10	46.0	15.2	0.7	-19.3
Feb 18	45.8	15.3	0.1	-19.5
Feb 26	45.5	15.3	359.6	-19.7
Mar 6	45.0	15.3	359.1	-19.9
Mar 14	44.5	15.2	358.7	-20.0
Mar 22	44.0	15.1	358.5	-20.1
Mar 30	43.4	15.0	358.3	-20.2
Apr 7	42.8	14.8	358.3	-20.2
Apr 15	42.2	14.5	358.4	-20.1
Apr 23	41.5	14.3	358.6	-20.1
May 1	40.9	14.0	358.9	-20.0
May 9	40.4	13.7	359.3	-19.8
May 17	39.8	13.4	359.8	-19.6
May 25	39.3	13.1	0.4	-19.4
Jun 2	38.8	12.8	1.1	-19.2
Jun 10	38.4	12.5	1.9	-18.9
Jun 18	38.1	12.1	2.6	-18.6
Jun 26	37.7	11.8	3.5	-18.3
Jul 4	37.5	11.5	4.4	-17.9
Jul 12	37.3	11.2	5.3	-17.6
Jul 20	37.1	11.0	6.3	-17.2
Jul 28	37.0	10.7	7.3	-16.8
Aug 5	37.0	10.4	8.2	-16.4
Aug 13	37.0	10.2	9.2	-16.0
Aug 21	37.0	9.9	10.2	-15.6
Aug 29	37.1	9.7	11.1	-15.2
Sep 6	37.3	9.5	12.1	-14.8
Sep 14	37.6	9.3	13.0	-14.4
Sep 22	37.8	9.2	13.8	-14.0
Sep 30	38.2	9.0	14.6	-13.7
Oct 8	38.6	8.9	15.3	-13.4
Oct 16	39.0	8.8	16.0	-13.1
Oct 24	39.5	8.8	16.6	-12.8
Nov 1	40.0	8.7	17.1	-12.6
Nov 9	40.6	8.7	17.6	-12.4
Nov 17	41.2	8.8	17.9	-12.3
Nov 25	41.8	8.9	18.1	-12.2
Dec 3	42.4	9.0	18.2	-12.2
Dec 11	43.0	9.1	18.2	-12.3
Dec 19	43.6	9.3	18.1	-12.3
Dec 27	44.1	9.5	17.9	-12.5

The Appearance of the Planets diagrams in Part I show how open the rings are for 2006. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28°. Saturn's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every 7 years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were edge-on during 1995 and will be again in 2009. During 2006 they are continuing to close up, down to around 12° by year's end.

Major and minor axes (in arc seconds) are for the outer edge of the outer ring. To work out the size of the other rings, multiply by the following factors.

Inner edge of outer ring	0.8932
Outer edge of inner ring	0.8596
Inner edge of inner ring	0.6726
Inner edge of dusky ring	0.5477

'U' and 'B' are the geocentric longitude and the tilt of the rings respectively.

Table 4: **Iapetus**

Magnitude [1]	11.0
Max Elong. [1]	9' 35"
Period (days) [2]	79.921

Elongation East		Inferior Conjunction		Elongation West		Superior Conjunction	
						Jan	10.888
Jan	31.192	Feb	20.133	Mar	10.708	Mar	30.188
Apr	19.571	May	10.358	May	29.429	Jun	18.483
Jul	9.542	Jul	30.408	Aug	18.983	Sep	7.996
Sep	29.355	Oct	19.617	Nov	8.196	Nov	27.688
Dec	18.575						

Notes 1. When at opposition
2. Mean Synodic Period

Iapetus

This moon's orbit is too large to place on the 'Apparent Orbits' diagram. The shape of its orbit is similar to the others and also orbits clockwise, however its orbit is over twice the diameter of Hyperion. In fact, even when you know its general direction it can sometimes be difficult to distinguish it from similar brightness background stars. Table 4 shows all the moon's greatest elongations East, Inferior Conjunctions, Greatest Elongation West and Superior Conjunctions for the year. These roughly correspond to the East, North, West and South positions respectively. For example, on March 20 Iapetus will be approximately halfway between a greatest Elongation West and a Superior Conjunction, placing the satellite SW of Saturn.

URANUS

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan 7	09:21	22:16	09:00	21:42	09:08	22:05	10:10	22:30	09:07	22:21	09:22	22:24	09:24	22:14	09:01	21:55
14	08:54	21:50	08:34	21:15	08:42	21:38	09:44	22:03	08:41	21:54	08:56	21:57	08:58	21:48	08:35	21:28
21	08:28	21:23	08:08	20:49	08:16	21:11	09:18	21:37	08:15	21:27	08:30	21:30	08:32	21:21	08:09	21:02
28	08:03	20:56	07:42	20:22	07:50	20:45	08:52	21:10	07:50	21:01	08:04	21:04	08:06	20:54	07:43	20:35
Feb 4	07:37	20:30	07:16	19:56	07:25	20:18	08:26	20:44	07:24	20:34	07:39	20:37	07:40	20:28	07:17	20:09
11	07:11	20:03	06:50	19:30	06:59	19:52	08:00	20:18	06:59	20:07	07:13	20:11	07:15	20:01	06:52	19:42
18	06:46	19:37	06:24	19:03	06:33	19:25	07:34	19:52	06:33	19:41	06:47	19:44	06:49	19:35	06:26	19:16
25	06:20	19:10	05:59	18:37	06:08	18:59	07:08	19:25	06:08	19:14	06:22	19:18	06:23	19:09	06:00	18:49
Mar 4	05:54	18:44	05:33	18:10	05:42	18:32	06:42	18:59	05:42	18:48	05:56	18:51	05:58	18:42	05:35	18:23
11	05:29	18:18	05:07	17:44	05:16	18:06	06:16	18:33	05:17	18:21	05:31	18:25	05:32	18:16	05:09	17:56
18	05:03	17:51	04:41	17:18	04:51	17:39	05:50	18:07	04:51	17:54	05:05	17:58	05:06	17:49	04:44	17:30
25	04:37	17:25	04:16	16:51	04:25	17:13	05:24	17:41	04:26	17:28	04:39	17:31	04:41	17:23	04:18	17:03
Apr 1	04:12	16:58	03:50	16:25	03:59	16:46	04:58	17:14	04:00	17:01	04:14	17:05	04:15	16:56	03:52	16:37
8	03:46	16:31	03:24	15:58	03:34	16:20	04:32	16:48	03:34	16:34	03:48	16:38	03:49	16:30	03:26	16:10
15	03:20	16:05	02:58	15:32	03:08	15:53	04:06	16:22	03:09	16:07	03:22	16:12	03:23	16:03	03:00	15:44
22	02:54	15:38	02:32	15:05	02:42	15:26	03:40	15:55	02:43	15:41	02:56	15:45	02:57	15:37	02:34	15:17
29	02:28	15:11	02:06	14:39	02:15	15:00	03:13	15:29	02:17	15:14	02:30	15:18	02:31	15:10	02:08	14:50
May 6	02:01	14:44	01:39	14:12	01:49	14:33	02:47	15:02	01:50	14:47	02:04	14:51	02:04	14:43	01:42	14:23
13	01:35	14:17	01:13	13:45	01:23	14:06	02:20	14:35	01:24	14:20	01:37	14:24	01:38	14:16	01:15	13:56
20	01:08	13:50	00:46	13:18	00:56	13:39	01:53	14:08	00:57	13:53	01:11	13:57	01:11	13:49	00:49	13:29
27	00:42	13:23	00:19	12:51	00:29	13:12	01:27	13:41	00:31	13:26	00:44	13:30	00:44	13:22	00:22	13:02
Jun 3	00:15	12:56	23:48	12:24	23:58	12:44	00:59	13:14	00:00	12:58	00:17	13:03	00:17	12:55	23:51	12:35
10	23:44	12:29	23:21	11:56	23:31	12:17	00:32	12:47	23:33	12:31	23:46	12:35	23:46	12:27	23:24	12:08
17	23:16	12:01	22:54	11:29	23:04	11:50	00:05	12:19	23:05	12:04	23:18	12:08	23:19	12:00	22:56	11:40
24	22:49	11:34	22:26	11:01	22:36	11:22	23:33	11:52	22:38	11:36	22:51	11:41	22:51	11:33	22:29	11:13
Jul 1	22:21	11:06	21:58	10:34	22:09	10:55	23:06	11:24	22:10	11:08	22:23	11:13	22:24	11:05	22:01	10:45
8	21:53	10:39	21:30	10:06	21:41	10:27	22:38	10:56	21:42	10:41	21:55	10:45	21:56	10:37	21:33	10:17
15	21:25	10:11	21:02	09:38	21:12	09:59	22:10	10:28	21:14	10:13	21:27	10:17	21:28	10:09	21:05	09:50
22	20:57	09:43	20:34	09:10	20:44	09:31	21:42	10:00	20:45	09:45	20:59	09:50	20:59	09:41	20:37	09:22
29	20:28	09:15	20:06	08:42	20:16	09:03	21:13	09:32	20:17	09:17	20:30	09:22	20:31	09:13	20:08	08:54
Aug 5	20:00	08:47	19:37	08:14	19:47	08:35	20:45	09:04	19:48	08:49	20:02	08:54	20:02	08:45	19:40	08:26
12	19:31	08:19	19:09	07:46	19:19	08:07	20:16	08:36	19:20	08:21	19:33	08:25	19:34	08:17	19:11	07:57
19	19:02	07:50	18:40	07:18	18:50	07:39	19:48	08:07	18:51	07:53	19:04	07:57	19:05	07:49	18:42	07:29
26	18:33	07:22	18:11	06:49	18:21	07:10	19:19	07:39	18:22	07:25	18:35	07:29	18:36	07:21	18:14	07:01
Sep 2	18:04	06:54	17:43	06:21	17:52	06:42	18:51	07:11	17:53	06:57	18:07	07:01	18:08	06:52	17:45	06:33
9	17:36	06:26	17:14	05:53	17:23	06:14	18:22	06:42	17:24	06:29	17:38	06:33	17:39	06:24	17:16	06:04
16	17:07	05:57	16:45	05:24	16:54	05:46	17:53	06:14	16:55	06:01	17:09	06:04	17:10	05:56	16:47	05:36
23	16:38	05:29	16:16	04:56	16:26	05:18	17:25	05:45	16:26	05:32	16:40	05:36	16:41	05:28	16:18	05:08
30	16:09	05:01	15:48	04:28	15:57	04:49	16:56	05:17	15:57	05:04	16:11	05:08	16:12	04:59	15:50	04:40
Oct 7	15:41	04:33	15:19	03:59	15:28	04:21	16:28	04:48	15:28	04:36	15:42	04:40	15:44	04:31	15:21	04:12
14	15:12	04:05	14:51	03:31	15:00	03:53	15:59	04:20	15:00	04:08	15:14	04:12	15:15	04:03	14:52	03:43
21	14:44	03:37	14:22	03:03	14:31	03:25	15:31	03:52	14:31	03:40	14:46	03:44	14:47	03:35	14:24	03:15
28	14:15	03:09	13:54	02:35	14:03	02:57	15:03	03:24	14:03	03:12	14:17	03:16	14:19	03:07	13:56	02:48
Nov 4	13:47	02:41	13:26	02:07	13:35	02:29	14:35	02:56	13:35	02:45	13:49	02:48	13:51	02:39	13:28	02:20
11	13:19	02:13	12:58	01:40	13:07	02:02	14:07	02:28	13:07	02:17	13:21	02:20	13:23	02:11	13:00	01:52
18	12:52	01:46	12:30	01:12	12:40	01:34	13:40	02:01	12:40	01:49	12:54	01:53	12:55	01:44	12:32	01:24
25	12:24	01:18	12:03	00:45	12:12	01:06	13:12	01:33	12:12	01:22	12:26	01:25	12:28	01:16	12:05	00:57
Dec 2	11:57	00:51	11:36	00:17	11:45	00:39	12:45	01:06	11:45	00:54	11:59	00:58	12:00	00:49	11:38	00:29
9	11:30	00:23	11:09	23:46	11:18	00:12	12:18	00:39	11:18	00:27	11:32	00:31	11:33	00:22	11:10	23:58
16	11:03	23:52	10:42	23:19	10:51	23:41	11:51	00:11	10:51	23:56	11:05	23:59	11:06	23:51	10:44	23:31
23	10:36	23:25	10:15	22:52	10:24	23:14	11:24	23:41	10:24	23:29	10:38	23:32	10:40	23:23	10:17	23:04
30	10:10	22:58	09:48	22:25	09:58	22:47	10:57	23:14	09:58	23:02	10:12	23:05	10:13	22:57	09:50	22:37

POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
22 39 18	- 09 18 39
22 40 25	- 09 11 47
22 41 38	- 09 04 20
22 42 56	- 08 56 22
22 44 18	- 08 48 00
22 45 44	- 08 39 17
22 47 12	- 08 30 21
22 48 41	- 08 21 16
22 50 12	- 08 12 07
22 51 41	- 08 03 02
22 53 10	- 07 54 05
22 54 36	- 07 45 21
22 55 59	- 07 36 56
22 57 19	- 07 28 55
22 58 34	- 07 21 24
22 59 43	- 07 14 26
23 00 46	- 07 08 06
23 01 43	- 07 02 29
23 02 33	- 06 57 37
23 03 14	- 06 53 34
23 03 48	- 06 50 22
23 04 13	- 06 48 03
23 04 29	- 06 46 39
23 04 37	- 06 46 09
23 04 36	- 06 46 35
23 04 26	- 06 47 54
23 04 07	- 06 50 06
23 03 41	- 06 53 07
23 03 06	- 06 56 53
23 02 25	- 07 01 22
23 01 38	- 07 06 27
23 00 46	- 07 12 01
22 59 49	- 07 18 00
22 58 49	- 07 24 15
22 57 47	- 07 30 39
22 56 44	- 07 37 05
22 55 42	- 07 43 23
22 54 42	- 07 49 28
22 53 45	- 07 55 10
22 52 53	- 08 00 23
22 52 05	- 08 05 01
22 51 24	- 08 08 58
22 50 51	- 08 12 09
22 50 25	- 08 14 29
22 50 08	- 08 15 55
22 50 00	- 08 16 26
22 50 01	- 08 16 00
22 50 12	- 08 14 36
22 50 32	- 08 12 16
22 51 01	- 08 09 00
22 51 40	- 08 04 51
22 52 26	- 07 59 50

SATELLITES OF URANUS AND NEPTUNE

This page is designed to help you find the position of Uranus' major satellites and Neptune's moon Triton. All dates/times are given in day/fractions in UT. You will need to convert your local time to this format first. Table 1 will help.

Uranus

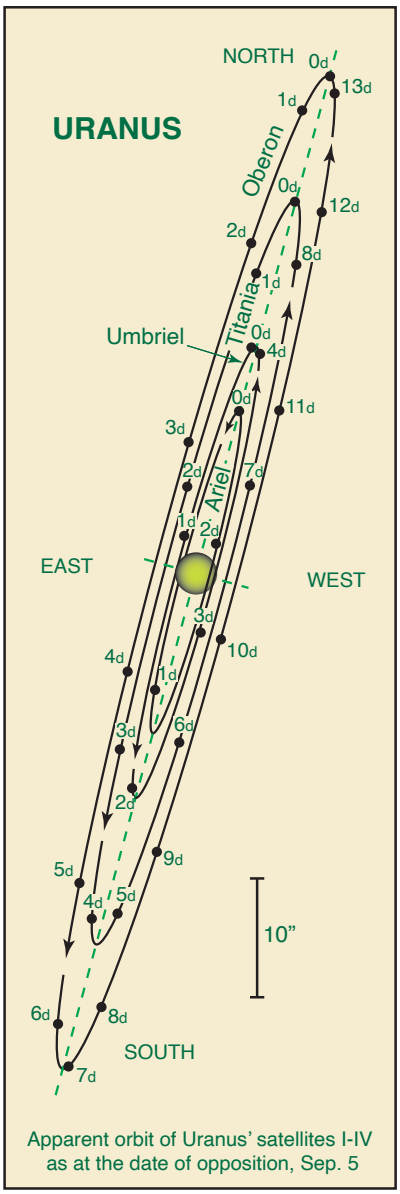
Table 2 presents the times of the first greatest elongation to the north for each month for **Ariel, Umbriel, Titania and Oberon**. This location is the day 0 (zero) point on the 'Apparent Orbits' diagram. Like with Saturn's satellites, the procedure is to work out how many orbits have elapsed since the first elongation of the month. Then discard the completed number of orbits and convert the remaining fraction back to days so its position can be read directly off the diagram. This is best illustrated with an example. You wish to determine the position of Umbriel for September 17 at 8pm EST.

1. Convert to UT as a fractional day. September 17 at 8pm (EST) = 17.417 UT
2. Subtract the date of the greatest elongation north for September, i.e. 17.417 – 1.600 = 15.817
3. Express this as the number of orbits by dividing by the period, i.e. 15.817 / 4.1442 = 3.817
4. Discard the 3 completed orbits leaves 0.817 (i.e., it is approximately 80% of the way around its orbit)
5. Multiply by the period, 0.817 X 4.1442 = 3.38 days.
6. Looking at the orbital path for Umbriel (see 'Apparent Orbit' diagram), the satellite is approximately northwest of Uranus and probably quite close to the planet (3" or 4" ?). This is not exactly the best time to try and observe this 14.5 magnitude object when it is so close to 6th magnitude Uranus! The next evening (18th) at this time is much more favourable. If you do the calculation, or just look at the diagram by adding one day, the moon will be very close and slightly past its greatest elongation north.

Table 1: Converting Time in Australia to Universal Time (UT) *

EST	WST	Fraction of day (UT)
6pm	4pm	0.333
7pm	5pm	0.375
8pm	6pm	0.417
9pm	7pm	0.458
10pm	8pm	0.500
11pm	9pm	0.542
midnight	10pm	0.583
1am	11pm	0.625
2am	midnight	0.667
3am	1am	0.708
4am	2am	0.750
5am	3am	0.792
6am	4am	0.833
7am	5am	0.875
8am	6am	0.917

* After midnight it is still the previous day in UT, for example 1am (EST) on the 21st = 20.625 days UT

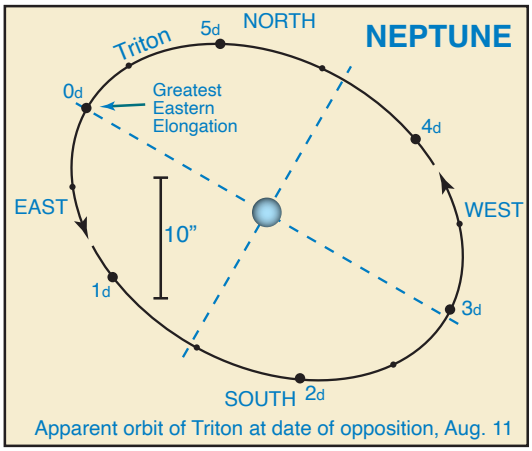


Apparent orbit of Uranus' satellites I-IV as at the date of opposition, Sep. 5

Neptune

The procedure for finding Triton is identical to above with the times of the first greatest elongation east for each month also being listed in Table 2. The orientation of Triton's orbit places this day 0 (zero) point closer to northeast of Neptune (see diagram)

An example. Estimate the position for Triton for July 18 at 10pm EST (18.500 UT). 2.412 orbits have elapsed since its greatest elongation east on July 4.325 UT. Discarding the 2 orbits leaves 0.412. Multiplying by 5.8768 (its period) gives 2.42 days. From the diagram the moon is southwest of Neptune.



Apparent orbit of Triton at date of opposition, Aug. 11

Table 2: Time of Greatest Elongation North/East (UT)

Planet	Uranus				Neptune
Moon	Ariel	Umbriel	Titania	Oberon	Triton
Magnitude [1]	13.7	14.5	13.5	13.7	13.5
Max Elong. [1]	0' 14"	0' 20"	0' 33"	0' 44"	0' 17"
Period (days) [2]	2.5204	4.1442	8.7059	13.4633	5.8768
Month	Elongation North (d.ddd)				East (d.ddd)
January	1.604	4.254	7.742	8.033	3.229
February	3.371	2.263	2.854	3.958	1.588
March	3.096	3.271	9.675	2.879	2.946
April	2.338	1.275	4.788	12.258	1.308
May	2.579	4.425	9.604	9.179	6.550
June	1.821	2.429	4.721	5.100	4.933
July	2.063	1.438	9.538	2.025	4.325
August	1.304	3.592	4.658	11.417	2.725
September	3.071	1.600	8.483	7.346	1.125
October	3.317	4.754	4.604	4.275	6.408
November	2.563	2.767	8.433	13.671	4.796
December	2.808	1.779	4.550	10.600	4.175

Notes 1. When at opposition
2. Mean Synodic Period

NEPTUNE

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan 7	07:35	21:12	07:20	20:33	07:23	21:01	08:39	21:11	07:15	21:24	07:35	21:22	07:41	21:08	07:17	20:50
14	07:09	20:46	06:54	20:06	06:56	20:34	08:13	20:45	06:49	20:57	07:08	20:55	07:15	20:41	06:50	20:23
21	06:43	20:19	06:27	19:39	06:30	20:07	07:46	20:18	06:23	20:30	06:42	20:29	06:49	20:14	06:24	19:57
28	06:17	19:52	06:01	19:13	06:04	19:41	07:20	19:51	05:56	20:03	06:16	20:02	06:22	19:48	05:58	19:30
Feb 4	05:50	19:25	05:35	18:46	05:38	19:14	06:54	19:25	05:30	19:37	05:50	19:35	05:56	19:21	05:32	19:03
11	05:24	18:59	05:08	18:19	05:11	18:47	06:27	18:58	05:04	19:10	05:23	19:08	05:30	18:54	05:05	18:36
18	04:58	18:32	04:42	17:53	04:45	18:20	06:01	18:32	04:38	18:43	04:57	18:42	05:04	18:28	04:39	18:10
25	04:32	18:05	04:16	17:26	04:19	17:54	05:34	18:05	04:12	18:16	04:31	18:15	04:37	18:01	04:13	17:43
Mar 4	04:05	17:38	03:49	16:59	03:53	17:27	05:08	17:39	03:46	17:49	04:05	17:48	04:11	17:34	03:47	17:16
11	03:39	17:12	03:23	16:32	03:26	17:00	04:41	17:12	03:19	17:22	03:38	17:21	03:45	17:07	03:20	16:49
18	03:13	16:45	02:57	16:06	03:00	16:33	04:15	16:45	02:53	16:56	03:12	16:54	03:18	16:41	02:54	16:23
25	02:46	16:18	02:30	15:39	02:33	16:06	03:48	16:19	02:27	16:29	02:45	16:27	02:52	16:14	02:27	15:56
Apr 1	02:19	15:51	02:03	15:12	02:07	15:39	03:21	15:52	02:00	16:02	02:19	16:00	02:25	15:47	02:01	15:29
8	01:53	15:24	01:37	14:45	01:40	15:12	02:55	15:25	01:33	15:34	01:52	15:33	01:58	15:20	01:34	15:02
15	01:26	14:57	01:10	14:18	01:13	14:45	02:28	14:58	01:07	15:07	01:25	15:06	01:32	14:53	01:07	14:35
22	00:59	14:30	00:43	13:51	00:46	14:18	02:01	14:31	00:40	14:40	00:59	14:39	01:05	14:26	00:40	14:08
29	00:32	14:02	00:16	13:24	00:19	13:51	01:34	14:04	00:13	14:13	00:32	14:12	00:38	13:58	00:13	13:40
May 6	00:05	13:35	23:45	12:56	23:48	13:24	01:06	13:36	23:42	13:46	00:04	13:45	00:10	13:31	23:42	13:13
13	23:34	13:08	23:18	12:29	23:21	12:56	00:39	13:09	23:15	13:18	23:33	13:17	23:39	13:04	23:15	12:46
20	23:06	12:40	22:50	12:02	22:54	12:29	00:12	12:42	22:47	12:51	23:06	12:50	23:12	12:36	22:48	12:18
27	22:39	12:13	22:23	11:34	22:26	12:01	23:40	12:14	22:20	12:23	22:38	12:22	22:44	12:09	22:20	11:51
Jun 3	22:11	11:45	21:55	11:06	21:58	11:34	23:13	11:46	21:52	11:56	22:11	11:55	22:17	11:41	21:52	11:23
10	21:43	11:18	21:27	10:39	21:31	11:06	22:45	11:19	21:24	11:28	21:43	11:27	21:49	11:14	21:24	10:55
17	21:15	10:50	20:59	10:11	21:03	10:38	22:17	10:51	20:56	11:00	21:15	10:59	21:21	10:46	20:57	10:28
24	20:47	10:22	20:31	09:43	20:35	10:11	21:49	10:23	20:28	10:33	20:47	10:31	20:53	10:18	20:29	10:00
Jul 1	20:19	09:54	20:03	09:15	20:07	09:43	21:21	09:55	20:00	10:05	20:19	10:04	20:25	09:50	20:00	09:32
8	19:51	09:26	19:35	08:47	19:38	09:15	20:53	09:27	19:32	09:37	19:50	09:36	19:57	09:22	19:32	09:04
15	19:23	08:58	19:07	08:19	19:10	08:47	20:25	08:59	19:03	09:09	19:22	09:08	19:28	08:54	19:04	08:36
22	18:54	08:30	18:38	07:51	18:42	08:19	19:56	08:31	18:35	08:41	18:54	08:40	19:00	08:26	18:36	08:08
29	18:26	08:02	18:10	07:23	18:13	07:51	19:28	08:03	18:06	08:13	18:25	08:12	18:31	07:58	18:07	07:40
Aug 5	17:57	07:34	17:42	06:55	17:45	07:23	19:00	07:34	17:38	07:45	17:57	07:44	18:03	07:30	17:39	07:12
12	17:29	07:06	17:13	06:27	17:16	06:55	18:32	07:06	17:09	07:17	17:28	07:16	17:35	07:02	17:10	06:44
19	17:01	06:38	16:45	05:59	16:48	06:26	18:03	06:38	16:41	06:49	17:00	06:47	17:06	06:34	16:42	06:16
26	16:32	06:10	16:16	05:31	16:20	05:58	17:35	06:10	16:12	06:21	16:31	06:19	16:38	06:06	16:13	05:48
Sep 2	16:04	05:42	15:48	05:02	15:51	05:30	17:07	05:42	15:44	05:53	16:03	05:51	16:09	05:38	15:45	05:20
9	15:35	05:14	15:20	04:34	15:23	05:02	16:38	05:14	15:15	05:25	15:35	05:23	15:41	05:10	15:17	04:52
16	15:07	04:46	14:52	04:06	14:55	04:34	16:10	04:45	14:47	04:57	15:06	04:55	15:13	04:42	14:48	04:24
23	14:39	04:18	14:23	03:38	14:26	04:06	15:42	04:17	14:19	04:29	14:38	04:27	14:45	04:14	14:20	03:56
30	14:11	03:50	13:55	03:10	13:58	03:39	15:14	03:49	13:51	04:01	14:10	04:00	14:17	03:46	13:52	03:28
Oct 7	13:43	03:22	13:27	02:43	13:30	03:11	14:46	03:22	13:23	03:33	13:42	03:32	13:49	03:18	13:24	03:00
14	13:15	02:54	12:59	02:15	13:02	02:43	14:18	02:54	12:55	03:06	13:14	03:04	13:21	02:50	12:56	02:32
21	12:47	02:27	12:32	01:47	12:35	02:15	13:51	02:26	12:27	02:38	12:46	02:36	12:53	02:22	12:29	02:05
28	12:20	01:59	12:04	01:20	12:07	01:48	13:23	01:59	12:00	02:10	12:19	02:09	12:25	01:55	12:01	01:37
Nov 4	11:52	01:32	11:37	00:52	11:40	01:20	12:56	01:31	11:32	01:43	11:51	01:41	11:58	01:27	11:33	01:09
11	11:25	01:04	11:09	00:25	11:12	00:53	12:28	01:04	11:05	01:16	11:24	01:14	11:31	01:00	11:06	00:42
18	10:58	00:37	10:42	23:54	10:45	00:25	12:01	00:36	10:38	00:48	10:57	00:47	11:03	00:33	10:39	00:15
25	10:31	00:10	10:15	23:26	10:18	23:54	11:34	00:09	10:10	00:21	10:30	00:19	10:36	00:05	10:12	23:44
Dec 2	10:04	23:39	09:48	22:59	09:51	23:27	11:07	23:38	09:44	23:50	10:03	23:48	10:09	23:34	09:45	23:16
9	09:37	23:11	09:21	22:32	09:24	23:00	10:40	23:11	09:17	23:23	09:36	23:21	09:42	23:07	09:18	22:49
16	09:10	22:45	08:54	22:05	08:57	22:33	10:13	22:44	08:50	22:56	09:09	22:54	09:16	22:40	08:51	22:22
23	08:43	22:18	08:28	21:38	08:31	22:06	09:46	22:17	08:24	22:29	08:43	22:27	08:49	22:13	08:25	21:55
30	08:17	21:51	08:01	21:11	08:04	21:39	09:20	21:51	07:57	22:02	08:16	22:00	08:23	21:46	07:58	21:28

POSITION

0hr UT Epoch 2000.0

RA	DEC
h m s	Set
21 14 25	- 16 09 42
21 15 23	- 16 05 23
21 16 24	- 16 00 52
21 17 26	- 15 56 13
21 18 29	- 15 51 29
21 19 32	- 15 46 43
21 20 35	- 15 41 58
21 21 37	- 15 37 18
21 22 36	- 15 32 46
21 23 33	- 15 28 26
21 24 27	- 15 24 19
21 25 17	- 15 20 30
21 26 02	- 15 17 01
21 26 43	- 15 13 54
21 27 19	- 15 11 12
21 27 49	- 15 08 56
21 28 13	- 15 07 08
21 28 31	- 15 05 49
21 28 43	- 15 05 01
21 28 48	- 15 04 43
21 28 47	- 15 04 54
21 28 40	- 15 05 36
21 28 27	- 15 06 47
21 28 08	- 15 08 24
21 27 44	- 15 10 27
21 27 15	- 15 12 53
21 26 41	- 15 15 39
21 26 04	- 15 18 42
21 25 24	- 15 21 59
21 24 41	- 15 25 27
21 23 57	- 15 29 01
21 23 12	- 15 32 37
21 22 27	- 15 36 12
21 21 43	- 15 39 42
21 21 00	- 15 43 03
21 20 21	- 15 46 11
21 19 44	- 15 49 03
21 19 12	- 15 51 35
21 18 44	- 15 53 46
21 18 21	- 15 55 31
21 18 04	- 15 56 51
21 17 53	- 15 57 42
21 17 49	- 15 58 04
21 17 51	- 15 57 56
21 18 00	- 15 57 18
21 18 15	- 15 56 09
21 18 37	- 15 54 30
21 19 05	- 15 52 23
21 19 39	- 15 49 48
21 20 19	- 15 46 48
21 21 03	- 15 43 23
21 21 52	- 15 39 37

PLUTO

RISE AND SET TIMES

EST, Adelaide and Darwin CST, Perth WST

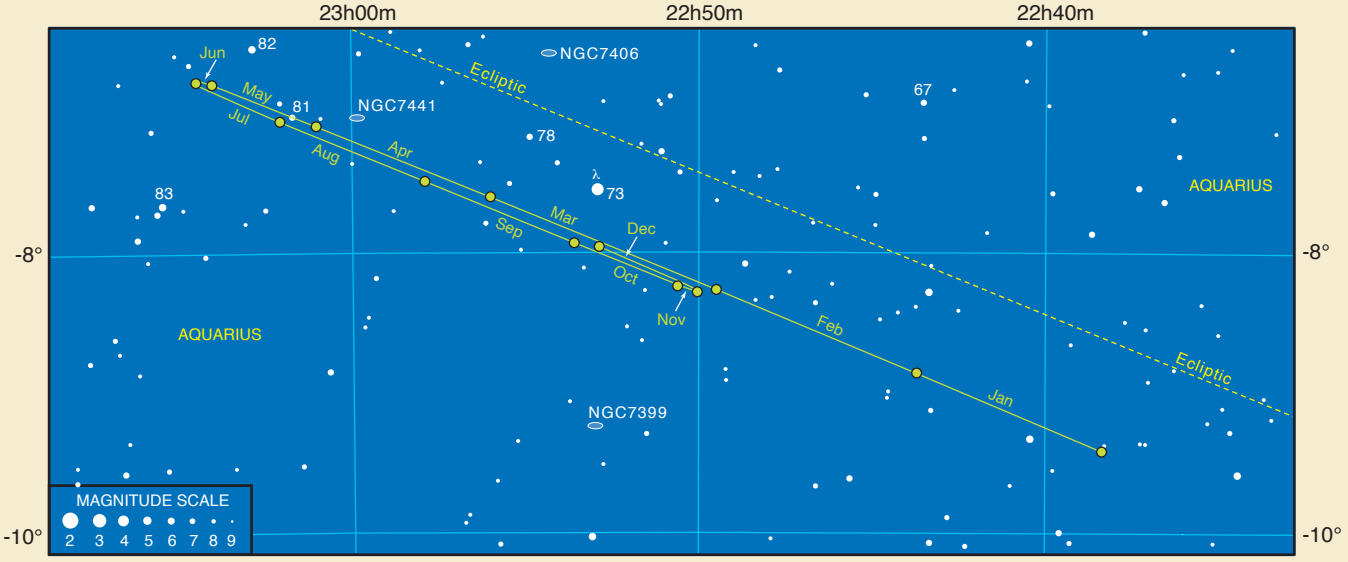
	Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Perth		Sydney	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan 7	04:02	17:37	03:46	16:58	03:49	17:26	05:05	17:37	03:42	17:49	04:01	17:47	04:08	17:33	03:43	17:15
14	03:35	17:11	03:20	16:31	03:23	16:59	04:39	17:10	03:15	17:22	03:35	17:20	03:41	17:06	03:17	16:49
21	03:09	16:44	02:53	16:05	02:56	16:33	04:12	16:44	02:49	16:55	03:08	16:54	03:14	16:40	02:50	16:22
28	02:42	16:17	02:27	15:38	02:29	16:06	03:45	16:17	02:22	16:29	02:41	16:27	02:48	16:13	02:23	15:55
Feb 4	02:15	15:51	02:00	15:11	02:03	15:39	03:19	15:50	01:55	16:02	02:15	16:00	02:21	15:47	01:57	15:29
11	01:49	15:24	01:33	14:45	01:36	15:13	02:52	15:23	01:29	15:35	01:48	15:34	01:54	15:20	01:30	15:02
18	01:22	14:57	01:06	14:18	01:09	14:46	02:25	14:57	01:02	15:08	01:21	15:07	01:28	14:53	01:03	14:35
25	00:55	14:30	00:39	13:51	00:42	14:19	01:58	14:30	00:35	14:41	00:54	14:40	01:01	14:26	00:36	14:08
Mar 4	00:28	14:03	00:12	13:24	00:15	13:52	01:31	14:02	00:08	14:14	00:27	14:13	00:34	13:59	00:09	13:41
11	23:57	13:36	23:41	12:56	23:44	13:24	01:04	13:35	23:37	13:47	23:56	13:45	00:06	13:31	23:38	13:14
18	23:30	13:08	23:14	12:29	23:17	12:57	00:37	13:08	23:10	13:20	23:29	13:18	23:35	13:04	23:11	12:46
25	23:02	12:41	22:47	12:02	22:50	12:30	00:09	12:41	22:42	12:52	23:01	12:51	23:08	12:37	22:44	12:19
Apr 1	22:35	12:13	22:19	11:34	22:22	12:02	23:38	12:13	22:15	12:25	22:34	12:23	22:40	12:09	22:16	11:51
8	22:07	11:46	21:52	11:06	21:55	11:34	23:10	11:45	21:47	11:57	22:06	11:55	22:13	11:42	21:48	11:24
15	21:40	11:18	21:24	10:39	21:27	11:07	22:43	11:18	21:20	11:29	21:39	11:28	21:45	11:14	21:21	10:56
22	21:12	10:50	20:56	10:11	20:59	10:39	22:15	10:50	20:52	11:01	21:11	11:00	21:17	10:46	20:53	10:28
29	20:44	10:22	20:28	09:43	20:31	10:11	21:47	10:22	20:24	10:33	20:43	10:32	20:50	10:18	20:25	10:00
May 6	20:16	09:54	20:00	09:15	20:03	09:43	21:19	09:54	19:56	10:05	20:15	10:04	20:22	09:50	19:57	09:32
13	19:48	09:26	19:32	08:47	19:35	09:15	20:51	09:26	19:28	09:37	19:47	09:36	19:54	09:22	19:29	09:04
20	19:20	08:58	19:04	08:19	19:07	08:46	20:23	08:58	19:00	09:09	19:19	09:07	19:25	08:54	19:01	08:36
27	18:52	08:30	18:36	07:50	18:39	08:18	19:54	08:29	18:32	08:41	18:51	08:39	18:57	08:25	18:33	08:07
Jun 3	18:23	08:01	18:08	07:22	18:11	07:50	19:26	08:01	18:03	08:12	18:23	08:11	18:29	07:57	18:05	07:39
10	17:55	07:33	17:39	06:54	17:42	07:22	18:58	07:33	17:35	07:44	17:54	07:43	18:01	07:29	17:36	07:11
17	17:27	07:05	17:11	06:26	17:14	06:53	18:30	07:05	17:07	07:16	17:26	07:14	17:32	07:01	17:08	06:43
24	16:58	06:37	16:43	05:57	16:46	06:25	18:01	06:36	16:39	06:48	16:58	06:46	17:04	06:32	16:40	06:14
Jul 1	16:30	06:08	16:14	05:29	16:18	05:57	17:33	06:08	16:10	06:20	16:30	06:18	16:36	06:04	16:11	05:46
8	16:02	05:40	15:46	05:01	15:49	05:29	17:05	05:40	15:42	05:51	16:01	05:50	16:08	05:36	15:43	05:18
15	15:34	05:12	15:18	04:33	15:21	05:01	16:37	05:12	15:14	05:23	15:33	05:22	15:39	05:08	15:15	04:50
22	15:05	04:44	14:50	04:05	14:53	04:33	16:09	04:44	14:46	04:55	15:05	04:54	15:11	04:40	14:47	04:22
29	14:37	04:16	14:22	03:37	14:25	04:05	15:40	04:16	14:17	04:27	14:37	04:26	14:43	04:12	14:19	03:54
Aug 5	14:09	03:48	13:54	03:09	13:57	03:37	15:12	03:48	13:49	03:59	14:08	03:58	14:15	03:44	13:51	03:26
12	13:41	03:20	13:26	02:41	13:29	03:09	14:44	03:20	13:21	03:32	13:40	03:30	13:47	03:16	13:22	02:58
19	13:13	02:53	12:58	02:13	13:01	02:41	14:17	02:52	12:53	03:04	13:13	03:02	13:19	02:48	12:55	02:30
26	12:45	02:25	12:30	01:45	12:33	02:13	13:49	02:24	12:25	02:36	12:45	02:35	12:51	02:21	12:27	02:03
Sep 2	12:18	01:57	12:02	01:18	12:05	01:46	13:21	01:57	11:58	02:09	12:17	02:07	12:23	01:53	11:59	01:35
9	11:50	01:30	11:35	00:50	11:37	01:19	12:54	01:29	11:30	01:41	11:49	01:40	11:56	01:26	11:31	01:08
16	11:23	01:03	11:07	00:23	11:10	00:51	12:26	01:02	11:02	01:14	11:22	01:12	11:28	00:58	11:04	00:40
23	10:55	00:35	10:40	23:52	10:42	00:24	11:59	00:35	10:35	00:47	10:54	00:45	11:01	00:31	10:36	00:13
30	10:28	00:08	10:12	23:25	10:15	23:53	11:32	00:07	10:07	00:20	10:27	00:18	10:34	00:04	10:09	23:42
Oct 7	10:01	23:38	09:45	22:58	09:48	23:26	11:04	23:36	09:40	23:49	10:00	23:47	10:06	23:33	09:42	23:15
14	09:33	23:11	09:18	22:31	09:21	22:59	10:37	23:10	09:13	23:22	09:33	23:21	09:39	23:06	09:15	22:49
21	09:06	22:44	08:51	22:04	08:54	22:33	10:10	22:43	08:46	22:56	09:05	22:54	09:12	22:40	08:48	22:22
28	08:39	22:17	08:24	21:37	08:27	22:06	09:44	22:16	08:19	22:29	08:39	22:27	08:45	22:13	08:21	21:55
Nov 4	08:13	21:51	07:57	21:11	08:00	21:39	09:17	21:49	07:52	22:02	08:12	22:01	08:19	21:46	07:54	21:28
11	07:46	21:24	07:31	20:44	07:33	21:13	08:50	21:23	07:25	21:36	07:45	21:34	07:52	21:20	07:27	21:02
18	07:19	20:58	07:04	20:18	07:06	20:46	08:24	20:56	06:59	21:09	07:18	21:07	07:25	20:53	07:00	20:35
25	06:53	20:31	06:37	19:51	06:40	20:20	07:57	20:29	06:32	20:43	06:52	20:41	06:58	20:27	06:34	20:09
Dec 2	06:26	20:05	06:11	19:25	06:13	19:53	07:30	20:03	06:05	20:17	06:25	20:15	06:32	20:00	06:07	19:42
9	05:59	19:38	05:44	18:58	05:47	19:27	07:04	19:37	05:39	19:50	05:58	19:48	06:05	19:34	05:41	19:16
16	05:33	19:12	05:18	18:32	05:20	19:01	06:37	19:10	05:12	19:24	05:32	19:22	05:39	19:08	05:14	18:50
23	05:06	18:46	04:51	18:06	04:54	18:34	06:11	18:44	04:46	18:58	05:05	18:55	05:12	18:41	04:48	18:23
30	04:40	18:19	04:25	17:39	04:27	18:08	05:44	18:17	04:19	18:31	04:39	18:29	04:46	18:15	04:21	17:57

POSITION

0hr UT Epoch 2000.0

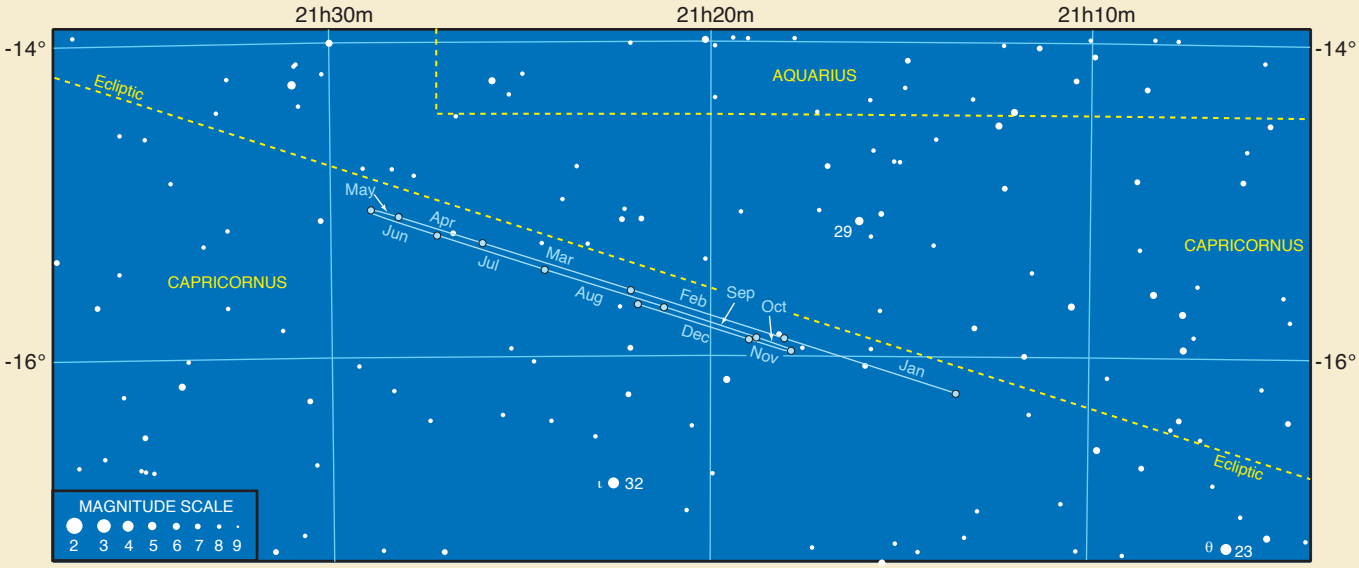
RA	DEC
h m s	Set
17 39 29	- 15 53 15
17 40 29	- 15 53 43
17 41 26	- 15 53 57
17 42 20	- 15 53 59
17 43 09	- 15 53 48
17 43 53	- 15 53 26
17 44 32	- 15 52 54
17 45 05	- 15 52 14
17 45 32	- 15 51 26
17 45 53	- 15 50 32
17 46 07	- 15 49 34
17 46 15	- 15 48 33
17 46 16	- 15 47 31
17 46 10	- 15 46 30
17 45 58	- 15 45 30
17 45 40	- 15 44 35
17 45 17	- 15 43 44
17 44 48	- 15 42 59
17 44 14	- 15 42 22
17 43 37	- 15 41 54
17 42 57	- 15 41 35
17 42 14	- 15 41 27
17 41 29	- 15 41 30
17 40 44	- 15 41 45
17 39 59	- 15 42 12
17 39 14	- 15 42 52
17 38 31	- 15 43 44
17 37 51	- 15 44 49
17 37 14	- 15 46 06
17 36 40	- 15 47 35
17 36 12	- 15 49 15
17 35 48	- 15 51 05
17 35 29	- 15 53 05
17 35 17	- 15 55 13
17 35 11	- 15 57 28
17 35 11	- 15 59 50
17 35 17	- 16 02 16
17 35 31	- 16 04 45
17 35 50	- 16 07 16
17 36 16	- 16 09 47
17 36 48	- 16 12 16
17 37 25	- 16 14 43
17 38 08	- 16 17 05
17 38 56	- 16 19 20
17 39 48	- 16 21 28
17 40 44	- 16 23 28
17 41 43	- 16 25 18
17 42 44	- 16 26 56
17 43 47	- 16 28 24
17 44 51	- 16 29 39
17 45 56	- 16 30 41
17 47 00	- 16 31 30

URANUS FINDER CHART



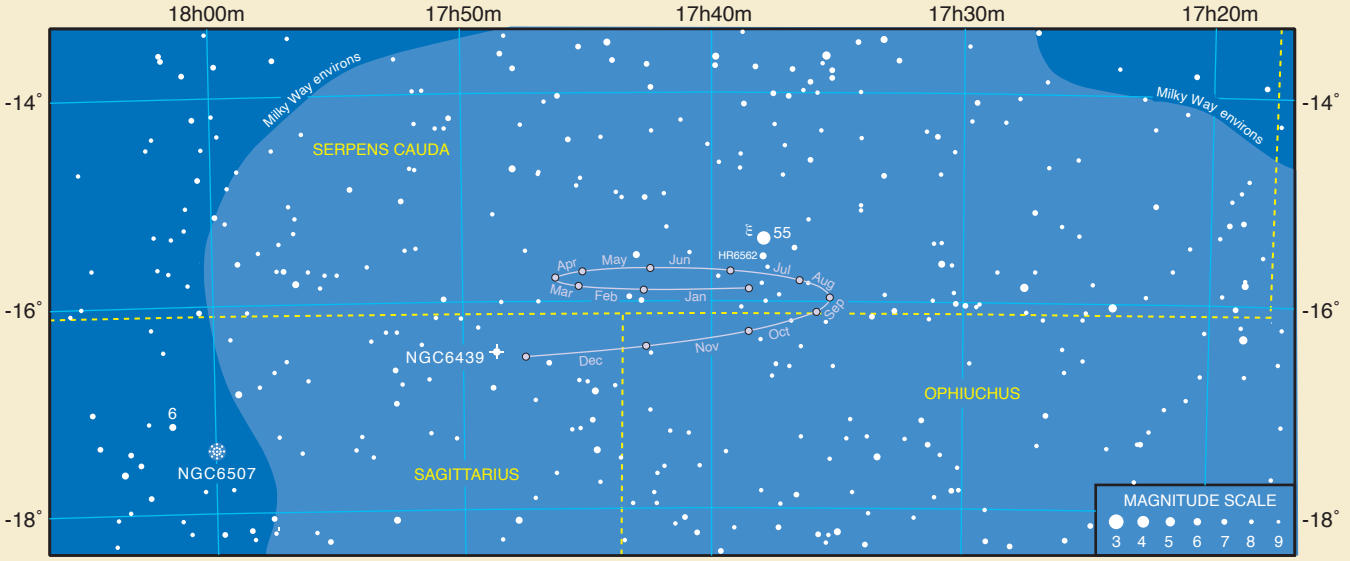
Conjunction 1st March, Stationary 20th June, Opposition 5th September, Stationary 21st November.

NEPTUNE FINDER CHART

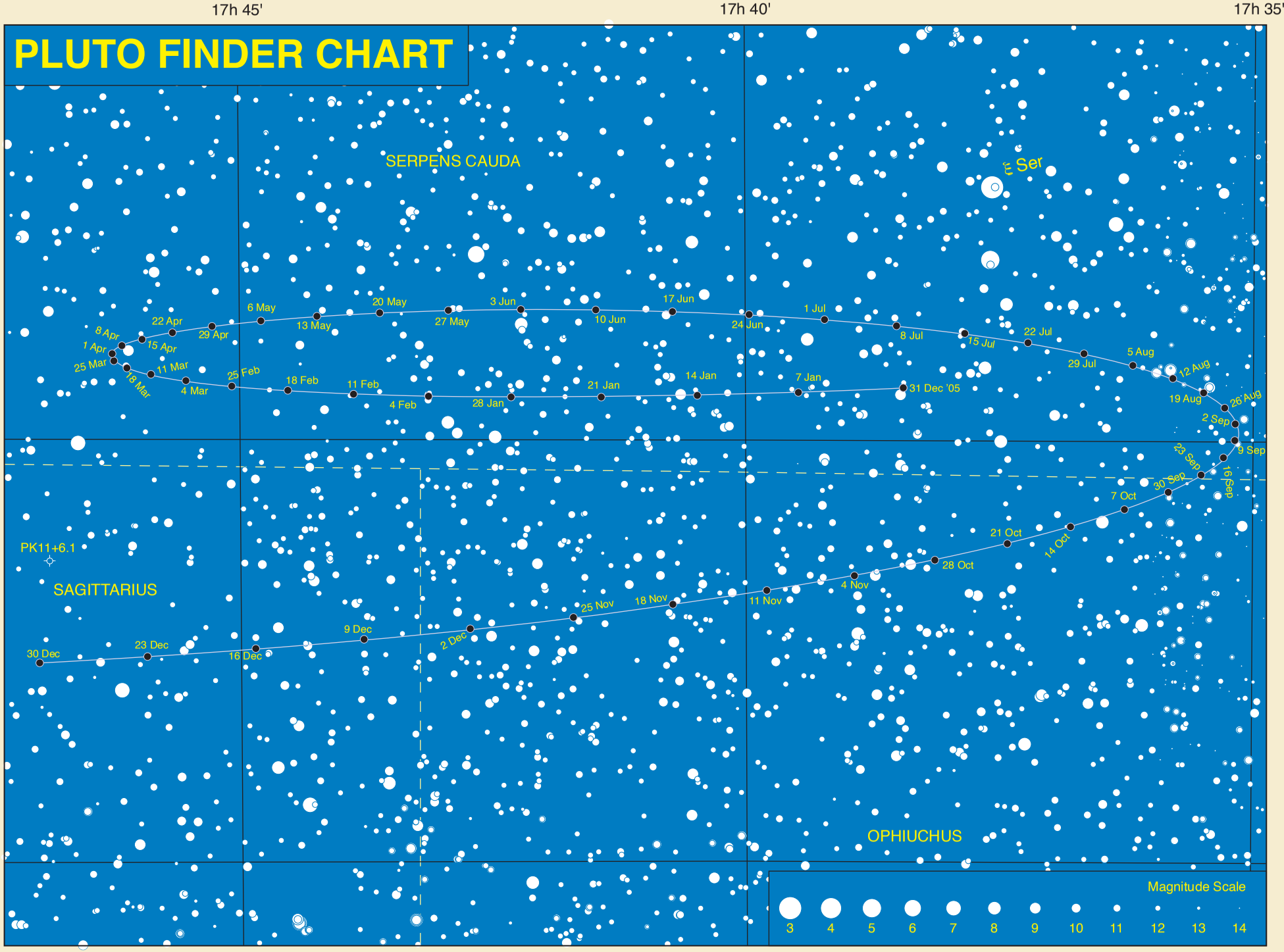


Conjunction 6th February, Stationary 23rd May, Opposition 11th August, Stationary 29th October.

PLUTO POINTER CHART



Stationary 30th March, Opposition 17th June, Stationary 5th September, Conjunction 19th December.


PLUTO FINDER CHART
17h 45'
17h 40'
17h 35'
6°
7°
SERPENS CAUDA
ξ Ser
SAGITTARIUS
PK11+6.1
OPHIUCHUS
Magnitude Scale
3 4 5 6 7 8 9 10 11 12 13 14
25 Mar
1 Apr
8 Apr
15 Apr
22 Apr
29 Apr
6 May
13 May
20 May
27 May
3 Jun
10 Jun
17 Jun
24 Jun
1 Jul
8 Jul
15 Jul
22 Jul
29 Jul
5 Aug
12 Aug
19 Aug
26 Aug
2 Sep
9 Sep
16 Sep
23 Sep
30 Sep
7 Oct
14 Oct
21 Oct
28 Oct
4 Nov
11 Nov
18 Nov
25 Nov
2 Dec
9 Dec
16 Dec
23 Dec
30 Dec
18 Mar
11 Mar
4 Mar
25 Feb
18 Feb
11 Feb
4 Feb
28 Jan
21 Jan
14 Jan
7 Jan
31 Dec '05

MINOR PLANET POSITIONS

(0HR UT, EPOCH 2000.0)

As well as the nine planets, their moons and the comets, the Solar System contains numerous smaller bodies known as the minor planets or asteroids. There are now hundreds of thousands of such bodies catalogued! Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe. Many can be found by photographing the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which 'star' has moved. Be sure you have the right field of view! Only about sixty of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition.

The ephemerides are for the twenty two brightest minor planets for 2006. Nineteen of these reach opposition in 2006, and three early in 2007. The selected asteroids are all about 10th magnitude or brighter around the time of opposition.

	1 CERES			2 PALLAS			3 JUNO			4 VESTA		
	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag	R.A. h mm	Dec ° '	Mag
Jan 7	18 47.1	- 25 30	8.8	17 14.2	+ 03 49	10.2	04 55.1	- 00 02	8.0	07 05.8	+ 22 56	6.3
14	18 59.6	- 25 26	8.9	17 24.5	+ 04 09	10.2	04 53.7	+ 00 59	8.1	06 58.0	+ 23 27	6.5
21	19 12.0	- 25 19	9.0	17 34.6	+ 04 34	10.2	04 53.8	+ 02 08	8.3	06 50.7	+ 23 56	6.6
28	19 24.3	- 25 08	9.1	17 44.4	+ 05 06	10.2	04 55.6	+ 03 21	8.5	06 44.3	+ 24 21	6.8
Feb 4	19 36.4	- 24 56	9.1	17 53.9	+ 05 42	10.2	04 58.8	+ 04 36	8.6	06 39.1	+ 24 43	6.9
11	19 48.3	- 24 40	9.2	18 02.9	+ 06 24	10.2	05 03.5	+ 05 50	8.8	06 35.4	+ 25 01	7.1
18	19 59.9	- 24 23	9.2	18 11.5	+ 07 11	10.2	05 09.5	+ 07 03	8.9	06 33.4	+ 25 16	7.2
25	20 11.3	- 24 04	9.2	18 19.6	+ 08 03	10.2	05 16.6	+ 08 13	9.1	06 32.9	+ 25 28	7.3
Mar 4	20 22.5	- 23 44	9.2	18 27.2	+ 09 00	10.2	05 24.7	+ 09 19	9.2	06 34.1	+ 25 37	7.4
11	20 33.3	- 23 23	9.2	18 34.1	+ 10 00	10.2	05 33.8	+ 10 21	9.3	06 36.8	+ 25 44	7.6
18	20 43.8	- 23 02	9.2	18 40.4	+ 11 05	10.1	05 43.7	+ 11 17	9.4	06 40.8	+ 25 48	7.7
25	20 53.9	- 22 41	9.2	18 46.0	+ 12 12	10.1	05 54.2	+ 12 07	9.6	06 46.2	+ 25 50	7.8
Apr 1	21 03.6	- 22 21	9.2	18 50.8	+ 13 22	10.1	06 05.3	+ 12 51	9.7	06 52.6	+ 25 49	7.8
8	21 12.8	- 22 01	9.2	18 54.8	+ 14 35	10.0	06 16.9	+ 13 29	9.8	07 00.0	+ 25 45	7.9
15	21 21.6	- 21 44	9.2	18 57.9	+ 15 47	10.0	06 28.9	+ 14 00	9.8	07 08.3	+ 25 38	8.0
22	21 29.9	- 21 29	9.1	19 00.0	+ 17 00	9.9	06 41.2	+ 14 25	9.9	07 17.4	+ 25 27	8.0
29	21 37.6	- 21 17	9.1	19 01.2	+ 18 12	9.9	06 53.9	+ 14 44	10.0	07 27.1	+ 25 13	8.1
May 6	21 44.7	- 21 08	9.0	19 01.3	+ 19 20	9.8	07 06.7	+ 14 56	10.1	07 37.4	+ 24 55	8.1
13	21 51.2	- 21 04	9.0	19 00.3	+ 20 24	9.8	07 19.6	+ 15 02	10.1	07 48.2	+ 24 34	8.2
20	21 56.9	- 21 05	8.9	18 58.3	+ 21 22	9.7	07 32.7	+ 15 02	10.2	07 59.3	+ 24 08	8.2
27	22 01.8	- 21 10	8.8	18 55.3	+ 22 13	9.7	07 45.8	+ 14 57	10.3	08 10.9	+ 23 39	8.2
Jun 3	22 05.8	- 21 22	8.7	18 51.4	+ 22 53	9.6	07 59.0	+ 14 46	10.3	08 22.7	+ 23 05	8.2
10	22 08.9	- 21 40	8.6	18 46.7	+ 23 22	9.6	08 12.1	+ 14 29	10.3	08 34.8	+ 22 27	8.2
17	22 11.0	- 22 04	8.5	18 41.3	+ 23 38	9.6	08 25.2	+ 14 08	10.4	08 47.0	+ 21 46	8.2
24	22 11.9	- 22 35	8.4	18 35.6	+ 23 40	9.5	08 38.2	+ 13 42	10.4	08 59.4	+ 21 00	8.2
Jul 1	22 11.8	- 23 12	8.3	18 29.7	+ 23 28	9.5	08 51.1	+ 13 12	10.4	09 11.9	+ 20 11	8.2
8	22 10.4	- 23 55	8.1	18 23.9	+ 23 02	9.5	09 03.9	+ 12 38	10.4	09 24.5	+ 19 18	8.2
15	22 07.9	- 24 41	8.0	18 18.5	+ 22 22	9.6	09 16.6	+ 12 00	10.5	09 37.2	+ 18 22	8.2
22	22 04.3	- 25 31	7.9	18 13.6	+ 21 30	9.6	09 29.2	+ 11 19	10.5	09 49.9	+ 17 22	8.2
29	21 59.7	- 26 20	7.8	18 09.5	+ 20 28	9.7	09 41.6	+ 10 35	10.5	10 02.7	+ 16 20	8.1
Aug 5	21 54.3	- 27 08	7.7	18 06.2	+ 19 17	9.7	09 53.9	+ 09 48	10.5	10 15.5	+ 15 14	8.1
12	21 48.3	- 27 52	7.6	18 03.9	+ 18 00	9.8	10 06.0	+ 09 00	10.4	10 28.3	+ 14 06	8.1
19	21 42.2	- 28 30	7.7	18 02.6	+ 16 39	9.9	10 17.9	+ 08 09	10.4	10 41.1	+ 12 55	8.0
26	21 36.1	- 29 00	7.8	18 02.3	+ 15 16	10.0	10 29.8	+ 07 17	10.4	10 53.9	+ 11 43	7.9
Sep 2	21 30.5	- 29 21	7.9	18 03.1	+ 13 52	10.0	10 41.4	+ 06 24	10.3	11 06.7	+ 10 29	7.9
9	21 25.6	- 29 33	8.0	18 04.8	+ 12 28	10.1	10 52.9	+ 05 30	10.4	11 19.5	+ 09 13	7.8
16	21 21.6	- 29 36	8.2	18 07.4	+ 11 07	10.2	11 04.2	+ 04 36	10.5	11 32.3	+ 07 56	7.8
23	21 18.7	- 29 30	8.3	18 10.8	+ 09 49	10.2	11 15.3	+ 03 41	10.6	11 45.2	+ 06 38	7.9
30	21 17.1	- 29 17	8.4	18 15.0	+ 08 35	10.3	11 26.3	+ 02 47	10.7	11 58.0	+ 05 20	7.9
Oct 7	21 16.7	- 28 57	8.5	18 20.0	+ 07 25	10.4	11 37.1	+ 01 53	10.7	12 10.9	+ 04 01	7.9
14	21 17.5	- 28 32	8.6	18 25.6	+ 06 21	10.4	11 47.7	+ 01 00	10.8	12 23.8	+ 02 43	8.0
21	21 19.4	- 28 01	8.7	18 31.8	+ 05 21	10.4	11 58.1	+ 00 09	10.8	12 36.7	+ 01 25	8.0
28	21 22.4	- 27 26	8.8	18 38.5	+ 04 27	10.5	12 08.3	- 00 41	10.8	12 49.6	+ 00 08	8.0
Nov 4	21 26.4	- 26 47	8.9	18 45.7	+ 03 38	10.5	12 18.2	- 01 29	10.9	13 02.6	- 01 08	8.0
11	21 31.3	- 26 04	9.0	18 53.3	+ 02 56	10.5	12 27.9	- 02 15	10.9	13 15.6	- 02 21	8.0
18	21 37.0	- 25 19	9.1	19 01.2	+ 02 19	10.6	12 37.3	- 02 58	10.9	13 28.5	- 03 33	8.0
25	21 43.3	- 24 30	9.1	19 09.5	+ 01 47	10.6	12 46.4	- 03 37	10.9	13 41.5	- 04 43	8.0
Dec 2	21 50.3	- 23 39	9.2	19 18.1	+ 01 22	10.6	12 55.1	- 04 14	10.9	13 54.5	- 05 50	8.0
9	21 57.8	- 22 45	9.2	19 26.9	+ 01 01	10.6	13 03.4	- 04 46	10.9	14 07.4	- 06 53	8.0
16	22 05.7	- 21 49	9.2	19 35.8	+ 00 46	10.6	13 11.4	- 05 14	10.9	14 20.3	- 07 53	7.9
23	22 14.0	- 20 50	9.3	19 44.9	+ 00 37	10.6	13 18.8	- 05 37	10.9	14 33.2	- 08 50	7.9
30	22 22.7	- 19 50	9.3	19 54.2	+ 00 32	10.5	13 25.6	- 05 55	10.8	14 45.9	- 09 42	7.9

	6 HEBE			7 IRIS			8 FLORA			9 METIS			10 HYGIEA			15 EUNOMIA		
Jan 7	17 39.6	- 13 35	11.0	19 48.2	- 18 33	10.4	15 06.2	- 12 09	11.7	11 31.9	+ 11 13	10.2	17 12.5	- 24 38	11.1	17 56.0	- 27 56	10.9
14	17 52.1	- 13 43	11.0	20 01.8	- 17 50	10.3	15 16.1	- 12 42	11.6	11 33.9	+ 11 27	10.1	17 25.2	- 24 47	11.1	18 08.5	- 27 47	10.9
21	18 04.6	- 13 46	11.0	20 15.5	- 17 03	10.2	15 25.7	- 13 10	11.6	11 34.3	+ 11 51	9.9	17 37.8	- 24 53	11.1	18 20.8	- 27 34	11.0
28	18 17.0	- 13 45	11.0	20 29.3	- 16 11	10.2	15 34.7	- 13 33	11.5	11 33.2	+ 12 22	9.8	17 50.1	- 24 55	11.1	18 33.0	- 27 18	11.0
Feb 4	18 29.3	- 13 39	11.0	20 43.0	- 15 14	10.2	15 43.3	- 13 53	11.5	11 30.5	+ 13 02	9.6	18 02.2	- 24 53	11.1	18 45.1	- 26 58	11.0
11	18 41.6	- 13 30	11.0	20 56.7	- 14 13	10.3	15 51.2	- 14 08	11.4	11 26.4	+ 13 46	9.5	18 14.0	- 24 48	11.1	18 56.9	- 26 36	11.0
18	18 53.6	- 13 16	11.0	21 10.4	- 13 07	10.3	15 58.4	- 14 19	11.3	11 21.0	+ 14 33	9.3	18 25.4	- 24 40	11.1	19 08.5	- 26 10	10.9
25	19 05.5	- 12 59	10.9	21 24.0	- 11 58	10.4	16 04.8	- 14 25	11.2	11 14.7	+ 15 20	9.2	18 36.4	- 24 28	11.1	19 19.8	- 25 42	10.9
Mar 4	19 17.2	- 12 39	10.9	21 37.6	- 10 45	10.4	16 10.3	- 14 28	11.1	11 07.9	+ 16 02	9.2	18 47.0	- 24 15	11.1	19 30.8	- 25 10	10.9
11	19 28.6	- 12 16	10.8	21 51.1	- 09 29	10.4	16 14.7	- 14 26	11.0	11 01.0	+ 16 38	9.3	18 57.0	- 23 59	11.0	19 41.5	- 24 37	10.8
18	19 39.7	- 11 50	10.8	22 04.6	- 08 09	10.4	16 18.0	- 14 21	10.9	10 54.5	+ 17 04	9.5	19 06.5	- 23 42	11.0	19 51.7	- 24 01	10.8
25	19 50.5	- 11 22	10.7	22 18.0	- 06 46	10.4	16 20.1	- 14 13	10.8	10 48.9	+ 17 20	9.6	19 15.3	- 23 23	11.0	20 01.4	- 23 24	10.7
Apr 1	20 00.9	- 10 53	10.7	22 31.4	- 05 21	10.4	16 20.7	- 14 01	10.6	10 44.4	+ 17 25	9.8	19 23.5	- 23 04	10.9	20 10.7	- 22 45	10.7
8	20 10.9	- 10 22	10.6	22 44.7	- 03 53	10.4	16 19.9	- 13 47	10.5	10 41.2	+ 17 19	10.0	19 30.8	- 22 45	10.8	20 19.5	- 22 05	10.6
15	20 20.5	- 09 51	10.5	22 58.0	- 02 23	10.3	16 17.7	- 13 30	10.3	10 39.5	+ 17 04	10.2	19 37.4	- 22 26	10.8	20 27.6	- 21 25	10.5
22	20 29.5	- 09 21	10.4	23 11.2	- 00 52	10.3	16 14.0	- 13 11	10.2	10 39.2	+ 16 40	10.3	19 43.0	- 22 07	10.7	20 35.1	- 20 44	10.5
29	20 38.0	- 08 51	10.3	23 24.4	+ 00 41	10.3	16 09.0	- 12 52	10.0	10 40.2	+ 16 08	10.5	19 47.7	- 21 50	10.6	20 41.8	- 20 03	10.4
May 6	20 45.8	- 08 24	10.2	23 37.6	+ 02 15	10.2	16 02.8	- 12 32	9.9	10 42.4	+ 15 30	10.6	19 51.3	- 21 35	10.5	20 47.7	- 19 23	10.2
13	20 53.0	- 07 59	10.1	23 50.7	+ 03 49	10.2	15 55.8	- 12 13	9.7	10 45.9	+ 14 46	10.8	19 53.8	- 21 22	10.4	20 52.8	- 18 44	10.1
20	20 59.3	- 07 39	9.9	00 03.8	+ 05 23	10.2	15 48.3	- 11 57	9.6	10 50.3	+ 13 57	10.9	19 55.0	- 21 12	10.3	20 56.9	- 18 06	10.0
27	21 04.8	- 07 24	9.8	00 16.9	+ 06 58	10.1	15 40.8	- 11 44	9.7	10 55.6	+ 13 04	11.0	19 55.1	- 21 04	10.2	20 59.9	- 17 30	9.9
Jun 3	21 09.3	- 07 15	9.6	00 30.0	+ 08 32	10.0	15 33.7	- 11 35	9.9	11 01.6	+ 12 07	11.1	19 54.0	- 20 59	10.1	21 01.8	- 16 56	9.7
10	21 12.8	- 07 15	9.5	00 43.1	+ 10 05	10.0	15 27.3	- 11 31	10.0	11 08.4	+ 11 07	11.2	19 51.6	- 20 57	9.9	21 02.4	- 16 25	9.6
17	21 15.0	- 07 24	9.3	00 56.1	+ 11 36	9.9	15 21.9	- 11 34	10.1	11 15.7	+ 10 03	11.3	19 48.1	- 20 57	9.8	21 01.8	- 15 56	9.4
24	21 16.0	- 07 44	9.1	01 09.1	+ 13 06	9.8	15 17.8	- 11 42	10.3	11 23.5	+ 08 58	11.4	19 43.6	- 20 59	9.7	20 59.8	- 15 31	9.3
Jul 1	21 15.7	- 08 17	8.9	01 22.0	+ 14 33	9.8	15 15.1	- 11 56	10.4	11 31.8	+ 07 50	11.4	19 38.3	- 21 03	9.5	20 56.4	- 15 09	9.1
8	21 14.0	- 09 02	8.7	01 34.9	+ 15 58	9.7	15 13.8	- 12 17	10.5	11 40.4	+ 06 40	11.5	19 32.6	- 21 07	9.3	20 51.8	- 14 50	8.9
15	21 11.0	- 10 01	8.5	01 47.6	+ 17 19	9.6	15 13.9	- 12 42	10.6	11 49.4	+ 05 28	11.5	19 26.6	- 21 10	9.2	20 46.1	- 14 35	8.7
22	21 06.7	- 11 12	8.3	02 00.1	+ 18 37	9.5	15 15.4	- 13 12	10.8	11 58.6	+ 04 16	11.6	19 20.8	- 21 13	9.5	20 39.5	- 14 21	8.5
29	21 01.5	- 12 33	8.1	02 12.3	+ 19 50	9.4	15 18.2	- 13 45	10.9	12 08.2	+ 03 02	11.6	19 15.4	- 21 16	9.7	20 32.4	- 14 10	8.4
Aug 5	20 55.7	- 14 03	7.8	02 24.3	+ 20 59	9.3	15 22.1	- 14 22	11.0	12 18.0	+ 01 47	11.6	19 10.7	- 21 17	9.8	20 25.1	- 14 00	8.4
12	20 49.8	- 15 36	8.0	02 35.7	+ 22 03	9.1	15 27.2	- 15 02	11.0	12 27.9	+ 00 32	11.7	19 07.0	- 21 16	10.0	20 18.2	- 13 51	8.6
19	20 44.0	- 17 09	8.1	02 46.7	+ 23 02	9.0	15 33.2	- 15 42	11.1	12 38.1	- 00 44	11.7	19 04.4	- 21 15	10.1	20 11.9	- 13 42	8.7
26	20 39.1	- 18 37	8.3	02 56.9	+ 23 55	8.9	15 40.2	- 16 25	11.2	12 48.5	- 01 59	11.7	19 02.9	- 21 12	10.3	20 06.7	- 13 33	8.8
Sep 2	20 35.4	- 19 57	8.4	03 06.2	+ 24 41	8.7	15 48.1	- 17 07	11.2	12 59.0	- 03 14	11.7	19 02.7	- 21 08	10.4	20 02.7	- 13 24	9.0
9	20 33.1	- 21 08	8.6	03 14.4	+ 25 21	8.6	15 56.8	- 17 49	11.3	13 09.7	- 04 29	11.7	19 03.6	- 21 03	10.5	20 00.2	- 13 15	9.1
16	20 32.5	- 22 07	8.7	03 21.4	+ 25 53	8.4	16 06.2	- 18 31	11.3	13 20.6	- 05 43	11.7	19 05.7	- 20 57	10.7	19 59.2	- 13 04	9.2
23	20 33.6	- 22 55	8.8	03 26.9	+ 26 17	8.2	16 16.3	- 19 11	11.4	13 31.6	- 06 56	11.6	19 08.8	- 20 50	10.8	19 59.8	- 12 51	9.3
30	20 36.5	- 23 31	9.0	03 30.7	+ 26 32	8.1	16 27.0	- 19 50	11.4	13 42.8	- 08 08	11.6	19 12.9	- 20 40	10.9	20 01.7	- 12 37	9.4
Oct 7	20 41.1	- 23 56	9.1	03 32.7	+ 26 37	7.9	16 38.3	- 20 26	11.4	13 54.1	- 09 19	11.6	19 18.0	- 20 29	11.0	20 05.1	- 12 20	9.5
14	20 47.2	- 24 10	9.2	03 32.7	+ 26 32	7.7	16 50.2	- 20 59	11.4	14 05.5	- 10 27	11.5	19 23.8	- 20 16	11.1	20 09.7	- 12 01	9.6
21	20 54.6	- 24 14	9.3	03 30.7	+ 26 14	7.5	17 02.5	- 21 29	11.4	14 17.0	- 11 34	11.5	19 30.3	- 20 01	11.1	20 15.5	- 11 38	9.7
28	21 03.3	- 24 08	9.4	03 27.1	+ 25 45	7.3	17 15.4	- 21 56	11.4	14 28.7	- 12 39	11.4	19 37.5	- 19 43	11.2	20 22.3	- 11 12	9.8
Nov 4	21 13.1	- 23 52	9.5	03 22.0	+ 25 03	7.0	17 28.7	- 22 18	11.4	14 40.4	- 13 41	11.3	19 45.3	- 19 23	11.3	20 30.1	- 10 42	9.8
11	21 23.9	- 23 28	9.6	03 16.2	+ 24 12	6.8	17 42.3	- 22 36	11.4	14 52.3	- 14 41	11.4	19 53.5	- 19 00	11.3	20 38.6	- 10 08	9.9
18	21 35.4	- 22 55	9.7	03 10.2	+ 23 13	6.8	17 56.3	- 22 49	11.4	15 04.2	- 15 38	11.5	20 02.2	- 18 34	11.4	20 47.9	- 09 29	9.9
25	21 47.6	- 22 14	9.7	03 04.7	+ 22 11	7.0	18 10.7	- 22 58	11.3	15 16.2	- 16 32	11.5	20 11.2	- 18 05	11.4	20 57.8	- 08 47	10.0
Dec 2	22 00.3	- 21 26	9.8	03 00.4	+ 21 10	7.3	18 25.3	- 23 00	11.3	15 28.2	- 17 22	11.6	20 20.5	- 17 34	11.4	21 08.3	- 08 00	10.0
9	22 13.5	- 20 30	9.8	02 57.6	+ 20 15	7.5	18 40.1	- 22 58	11.3	15 40.2	- 18 10	11.7	20 30.1	- 17 00	11.4	21 19.3	- 07 08	10.0
16	22 27.1	- 19 28	9.9	02 56.6	+ 19 29	7.7	18 55.2	- 22 50	11.2	15 52.3	- 18 54	11.7	20 39.8	- 16 22	11.5	21 30.6	- 06 12	10.1
23	22 41.0	- 18 20	9.9	02 57.4	+ 18 52	7.9	19 10.4	- 22 36	11.2	16 04.3	- 19 34	11.7	20 49.7	- 15 42	11.5	21 42.4	- 05 11	10.1
30	22 55.2	- 17 06	9.9	03 00.0	+ 18 27	8.2	19 25.7	- 22 16	11.1	16 16.2	- 20 11	11.8	20 59.7	- 14 59	11.5	21 54.5	- 04 06	10.1

	18 MELPOMENE			20 MASSALIA			22 KALLIOPE			29 AMPHITRITE			39 LAETITIA			40 HARMONIA		
	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag
	h mm	° '		h mm	° '		h mm	° '		h mm	° '		h mm	° '		h mm	° '	
Jan 7	21 20.4	- 15 53	10.8	22 59.8	- 06 10	11.5	23 28.4	- 15 02	11.9	17 11.9	- 27 28	11.4	22 02.7	- 12 58	11.4	11 48.1	+ 06 24	11.2
14	21 37.0	- 14 55	10.7	23 10.2	- 05 06	11.5	23 37.1	- 13 38	12.0	17 24.7	- 27 46	11.4	22 14.9	- 12 07	11.4	11 50.9	+ 06 26	11.1
21	21 53.8	- 13 51	10.7	23 21.0	- 04 00	11.5	23 46.0	- 12 14	12.0	17 37.3	- 28 00	11.4	22 27.3	- 11 12	11.4	11 52.4	+ 06 39	11.0
28	22 10.6	- 12 42	10.7	23 32.1	- 02 50	11.5	23 55.3	- 10 48	12.0	17 49.9	- 28 12	11.4	22 39.7	- 10 14	11.3	11 52.4	+ 07 00	10.8
Feb 4	22 27.4	- 11 28	10.6	23 43.4	- 01 38	11.5	00 04.9	- 09 22	12.0	18 02.1	- 28 20	11.4	22 52.1	- 09 13	11.3	11 50.9	+ 07 31	10.6
11	22 44.2	- 10 10	10.6	23 55.0	- 00 24	11.5	00 14.6	- 07 55	12.0	18 14.2	- 28 25	11.4	23 04.6	- 08 10	11.3	11 48.0	+ 08 10	10.5
18	23 01.0	- 08 48	10.5	00 06.8	+ 00 51	11.5	00 24.6	- 06 29	12.0	18 25.9	- 28 28	11.4	23 17.2	- 07 06	11.2	11 43.7	+ 08 55	10.3
25	23 17.9	- 07 22	10.5	00 18.9	+ 02 08	11.5	00 34.8	- 05 02	11.9	18 37.3	- 28 28	11.4	23 29.7	- 06 00	11.2	11 38.3	+ 09 45	10.1
Mar 4	23 34.7	- 05 55	10.4	00 31.1	+ 03 26	11.4	00 45.2	- 03 36	11.9	18 48.3	- 28 27	11.3	23 42.3	- 04 53	11.1	11 31.9	+ 10 36	9.9
11	23 51.5	- 04 25	10.3	00 43.6	+ 04 44	11.4	00 55.7	- 02 10	11.9	18 58.8	- 28 24	11.3	23 54.9	- 03 45	11.0	11 25.1	+ 11 25	9.9
18	00 08.4	- 02 55	10.3	00 56.2	+ 06 03	11.3	01 06.4	- 00 45	11.8	19 08.8	- 28 20	11.2	00 07.5	- 02 37	11.0	11 18.3	+ 12 09	10.0
25	00 25.3	- 01 24	10.2	01 09.0	+ 07 21	11.3	01 17.2	+ 00 39	11.8	19 18.2	- 28 16	11.2	00 20.1	- 01 29	10.9	11 12.0	+ 12 45	10.2
Apr 1	00 42.2	+ 00 07	10.2	01 22.1	+ 08 38	11.2	01 28.1	+ 02 02	11.7	19 27.0	- 28 12	11.1	00 32.7	- 00 22	11.0	11 06.4	+ 13 11	10.4
8	00 59.2	+ 01 36	10.3	01 35.3	+ 09 55	11.1	01 39.1	+ 03 23	11.7	19 35.0	- 28 09	11.1	00 45.3	+ 00 45	11.1	11 02.0	+ 13 27	10.6
15	01 16.2	+ 03 04	10.3	01 48.8	+ 11 10	11.0	01 50.2	+ 04 42	11.6	19 42.2	- 28 07	11.0	00 57.9	+ 01 50	11.1	10 58.9	+ 13 32	10.7
22	01 33.3	+ 04 30	10.4	02 02.4	+ 12 23	10.9	02 01.4	+ 06 00	11.6	19 48.5	- 28 07	10.9	01 10.5	+ 02 54	11.2	10 57.2	+ 13 27	10.9
29	01 50.4	+ 05 53	10.4	02 16.2	+ 13 34	10.9	02 12.7	+ 07 16	11.6	19 53.9	- 28 09	10.8	01 23.0	+ 03 55	11.2	10 57.0	+ 13 13	11.0
May 6	02 07.6	+ 07 12	10.5	02 30.3	+ 14 43	11.0	02 24.1	+ 08 29	11.7	19 58.1	- 28 14	10.7	01 35.6	+ 04 54	11.3	10 58.1	+ 12 50	11.2
13	02 24.9	+ 08 27	10.5	02 44.5	+ 15 48	11.1	02 35.6	+ 09 40	11.7	20 01.2	- 28 22	10.6	01 48.1	+ 05 51	11.3	11 00.4	+ 12 19	11.3
20	02 42.1	+ 09 38	10.5	02 59.0	+ 16 50	11.1	02 47.1	+ 10 48	11.8	20 03.0	- 28 34	10.4	02 00.5	+ 06 45	11.3	11 04.0	+ 11 42	11.4
27	02 59.5	+ 10 43	10.6	03 13.6	+ 17 49	11.1	02 58.7	+ 11 54	11.8	20 03.4	- 28 49	10.3	02 12.9	+ 07 35	11.4	11 08.5	+ 10 58	11.5
Jun 3	03 16.8	+ 11 42	10.6	03 28.4	+ 18 43	11.2	03 10.3	+ 12 57	11.8	20 02.5	- 29 07	10.2	02 25.3	+ 08 22	11.4	11 14.0	+ 10 09	11.6
10	03 34.2	+ 12 35	10.6	03 43.4	+ 19 33	11.2	03 21.9	+ 13 57	11.9	20 00.0	- 29 27	10.0	02 37.5	+ 09 05	11.4	11 20.3	+ 09 16	11.7
17	03 51.5	+ 13 22	10.7	03 58.6	+ 20 18	11.2	03 33.5	+ 14 54	11.9	19 56.2	- 29 48	9.9	02 49.6	+ 09 44	11.4	11 27.4	+ 08 18	11.8
24	04 08.8	+ 14 03	10.7	04 13.9	+ 20 58	11.2	03 45.0	+ 15 47	11.9	19 51.0	- 30 10	9.7	03 01.6	+ 10 19	11.4	11 35.0	+ 07 17	11.9
Jul 1	04 26.0	+ 14 36	10.7	04 29.3	+ 21 33	11.2	03 56.6	+ 16 38	11.9	19 44.7	- 30 29	9.6	03 13.4	+ 10 49	11.4	11 43.3	+ 06 13	11.9
8	04 43.0	+ 15 02	10.7	04 44.7	+ 22 03	11.2	04 08.0	+ 17 26	11.9	19 37.7	- 30 44	9.4	03 25.0	+ 11 14	11.4	11 52.0	+ 05 06	12.0
15	04 59.9	+ 15 22	10.8	05 00.3	+ 22 26	11.2	04 19.4	+ 18 10	11.9	19 30.3	- 30 55	9.4	03 36.3	+ 11 35	11.4	12 01.1	+ 03 56	12.0
22	05 16.6	+ 15 34	10.8	05 15.8	+ 22 44	11.2	04 30.6	+ 18 52	11.9	19 22.9	- 30 59	9.5	03 47.4	+ 11 51	11.3	12 10.7	+ 02 44	12.1
29	05 33.0	+ 15 40	10.8	05 31.4	+ 22 56	11.2	04 41.6	+ 19 30	11.9	19 16.0	- 30 57	9.6	03 58.0	+ 12 01	11.3	12 20.6	+ 01 31	12.1
Aug 5	05 49.1	+ 15 39	10.8	05 46.8	+ 23 03	11.2	04 52.4	+ 20 06	11.8	19 09.9	- 30 49	9.8	04 08.3	+ 12 07	11.3	12 30.8	+ 00 16	12.1
12	06 04.8	+ 15 32	10.8	06 02.2	+ 23 03	11.1	05 02.9	+ 20 40	11.8	19 05.0	- 30 36	9.9	04 18.1	+ 12 08	11.2	12 41.3	- 01 00	12.1
19	06 20.1	+ 15 19	10.8	06 17.4	+ 22 58	11.1	05 13.0	+ 21 11	11.8	19 01.5	- 30 18	10.0	04 27.3	+ 12 03	11.2	12 52.1	- 02 16	12.1
26	06 35.0	+ 15 01	10.8	06 32.4	+ 22 48	11.1	05 22.8	+ 21 41	11.7	18 59.4	- 29 58	10.2	04 35.9	+ 11 54	11.1	13 03.2	- 03 33	12.1
Sep 2	06 49.4	+ 14 38	10.8	06 47.2	+ 22 32	11.0	05 32.0	+ 22 09	11.6	18 58.9	- 29 34	10.3	04 43.7	+ 11 40	11.1	13 14.6	- 04 50	12.1
9	07 03.3	+ 14 10	10.8	07 01.6	+ 22 11	11.0	05 40.8	+ 22 37	11.6	18 59.8	- 29 09	10.4	04 50.8	+ 11 21	11.0	13 26.2	- 06 06	12.1
16	07 16.5	+ 13 39	10.8	07 15.6	+ 21 46	10.9	05 48.8	+ 23 04	11.5	19 02.2	- 28 43	10.5	04 56.9	+ 10 58	10.9	13 38.1	- 07 22	12.1
23	07 29.1	+ 13 05	10.8	07 29.3	+ 21 17	10.9	05 56.2	+ 23 31	11.4	19 05.8	- 28 15	10.6	05 01.9	+ 10 32	10.8	13 50.1	- 08 37	12.1
30	07 41.0	+ 12 28	10.7	07 42.4	+ 20 45	10.8	06 02.7	+ 23 59	11.3	19 10.7	- 27 46	10.7	05 05.9	+ 10 01	10.7	14 02.5	- 09 51	12.1
Oct 7	07 52.1	+ 11 50	10.7	07 55.0	+ 20 10	10.7	06 08.2	+ 24 28	11.3	19 16.6	- 27 16	10.8	05 08.6	+ 09 29	10.6	14 15.1	- 11 03	12.0
14	08 02.4	+ 11 12	10.7	08 07.0	+ 19 33	10.7	06 12.7	+ 24 59	11.1	19 23.5	- 26 44	10.9	05 10.0	+ 08 54	10.5	14 27.8	- 12 13	12.0
21	08 11.8	+ 10 33	10.6	08 18.2	+ 18 55	10.6	06 15.9	+ 25 33	11.0	19 31.2	- 26 11	10.9	05 10.0	+ 08 18	10.4	14 40.9	- 13 21	11.9
28	08 20.2	+ 09 56	10.5	08 28.7	+ 18 17	10.5	06 17.8	+ 26 09	10.9	19 39.6	- 25 35	11.0	05 08.6	+ 07 42	10.2	14 54.1	- 14 26	11.8
Nov 4	08 27.5	+ 09 22	10.5	08 38.3	+ 17 39	10.4	06 18.3	+ 26 49	10.8	19 48.7	- 24 57	11.0	05 05.8	+ 07 08	10.1	15 07.6	- 15 28	11.8
11	08 33.6	+ 08 51	10.4	08 46.9	+ 17 03	10.3	06 17.2	+ 27 31	10.6	19 58.4	- 24 17	11.1	05 01.8	+ 06 36	10.0	15 21.3	- 16 27	11.7
18	08 38.4	+ 08 25	10.3	08 54.4	+ 16 30	10.2	06 14.6	+ 28 16	10.5	20 08.5	- 23 34	11.1	04 56.7	+ 06 09	9.9	15 35.1	- 17 22	11.6
25	08 41.8	+ 08 05	10.2	09 00.7	+ 16 00	10.0	06 10.5	+ 29 01	10.4	20 19.0	- 22 48	11.1	04 50.8	+ 05 48	9.8	15 49.2	- 18 13	11.6
Dec 2	08 43.6	+ 07 53	10.1	09 05.6	+ 15 36	9.9	06 05.0	+ 29 46	10.2	20 29.9	- 21 59	11.2	04 44.6	+ 05 35	9.7	16 03.4	- 19 00	11.7
9	08 43.9	+ 07 49	10.0	09 09.0	+ 15 17	9.8	05 58.4	+ 30 28	10.1	20 41.0	- 21 07	11.2	04 38.2	+ 05 29	9.8	16 17.7	- 19 42	11.8
16	08 42.5	+ 07 56	9.9	09 10.9	+ 15 06	9.6	05 51.1	+ 31 06	9.9	20 52.4	- 20 11	11.2	04 32.2	+ 05 32	9.9	16 32.2	- 20 20	11.9
23	08 39.4	+ 08 13	9.7	09 10.9	+ 15 02	9.4	05 43.4	+ 31 39	10.0	21 03.9	- 19 13	11.2	04 26.9	+ 05 43	10.0	16 46.7	- 20 53	11.9
30	08 34.9	+ 08 41	9.6	09 09.3	+ 15 07	9.3	05 36.0	+ 32 06	10.1	21 15.6	- 18 11	11.2	04 22.6	+ 06 02	10.2	17 01.4	- 21 21	11.9

	44 NYSA			68 LETO			97 KLOTHO			349 DEMBOWSKA			532 HERCULINA			704 INTERAMNIA		
	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag	R.A.	Dec	Mag
	h mm	° '		h mm	° '		h mm	° '		h mm	° '		h mm	° '		h mm	° '	
Jan 7	22 34.8	- 11 09	12.1	18 49.6	- 27 40	11.8	21 28.6	- 13 39	13.0	18 36.0	- 28 44	11.5	16 04.4	- 08 37	10.8	19 03.6	- 21 44	11.5
14	22 45.2	- 10 08	12.1	19 04.4	- 27 27	11.9	21 40.4	- 12 58	13.0	18 48.6	- 28 37	11.5	16 16.9	- 09 08	10.8	19 15.1	- 21 07	11.6
21	22 55.8	- 09 05	12.1	19 19.2	- 27 10	12.0	21 52.4	- 12 14	12.9	19 01.2	- 28 27	11.6	16 29.2	- 09 34	10.8	19 26.4	- 20 27	11.7
28	23 06.6	- 07 59	12.1	19 34.0	- 26 48	12.0	22 04.6	- 11 25	12.9	19 13.7	- 28 14	11.6	16 41.1	- 09 56	10.8	19 37.7	- 19 43	11.8
Feb 4	23 17.6	- 06 51	12.1	19 48.7	- 26 21	12.0	22 17.0	- 10 34	12.8	19 26.0	- 27 58	11.6	16 52.6	- 10 13	10.7	19 48.8	- 18 56	11.8
11	23 28.8	- 05 41	12.1	20 03.2	- 25 51	12.1	22 29.4	- 09 39	12.7	19 38.2	- 27 40	11.6	17 03.6	- 10 26	10.7	19 59.7	- 18 06	11.9
18	23 40.1	- 04 30	12.1	20 17.7	- 25 16	12.1	22 42.0	- 08 41	12.6	19 50.2	- 27 20	11.6	17 14.1	- 10 34	10.7	20 10.5	- 17 13	11.9
25	23 51.6	- 03 17	12.0	20 32.0	- 24 38	12.1	22 54.7	- 07 41	12.5	20 02.0	- 26 58	11.6	17 23.9	- 10 39	10.6	20 21.0	- 16 17	12.0
Mar 4	00 03.2	- 02 03	12.0	20 46.1	- 23 56	12.1	23 07.5	- 06 39	12.3	20 13.5	- 26 34	11.6	17 33.1	- 10 41	10.6	20 31.4	- 15 18	12.0
11	00 14.9	- 00 49	11.9	21 00.1	- 23 11	12.1	23 20.4	- 05 35	12.3	20 24.7	- 26 09	11.6	17 41.6	- 10 40	10.5	20 41.4	- 14 16	12.0
18	00 26.8	+ 00 26	11.9	21 13.8	- 22 24	12.1	23 33.3	- 04 30	12.4	20 35.5	- 25 44	11.5	17 49.1	- 10 38	10.5	20 51.1	- 13 12	12.0
25	00 38.8	+ 01 41	11.8	21 27.2	- 21 35	12.1	23 46.4	- 03 24	12.4	20 46.1	- 25 18	11.5	17 55.8	- 10 34	10.4	21 00.6	- 12 06	12.0
Apr 1	00 50.9	+ 02 56	11.8	21 40.4	- 20 44	12.1	23 59.5	- 02 17	12.5	20 56.2	- 24 52	11.5	18 01.4	- 10 29	10.3	21 09.6	- 10 58	12.0
8	01 03.0	+ 04 10	11.7	21 53.3	- 19 52	12.0	00 12.8	- 01 10	12.5	21 05.9	- 24 27	11.4	18 05.8	- 10 25	10.2	21 18.3	- 09 48	11.9
15	01 15.4	+ 05 24	11.8	22 05.8	- 18 59	12.0	00 26.1	- 00 03	12.5	21 15.2	- 24 03	11.4	18 09.1	- 10 23	10.1	21 26.6	- 08 36	11.9
22	01 27.8	+ 06 36	11.8	22 18.1	- 18 06	12.0	00 39.6	+ 01 04	12.6	21 23.9	- 23 41	11.3	18 11.0	- 10 22	10.0	21 34.5	- 07 23	11.9
29	01 40.3	+ 07 47	11.8	22 30.0	- 17 13	11.9	00 53.1	+ 02 09	12.6	21 32.1	- 23 21	11.3	18 11.6	- 10 25	9.9	21 41.8	- 06 08	11.8
May 6	01 53.0	+ 08 56	11.8	22 41.5	- 16 21	11.9	01 06.8	+ 03 14	12.6	21 39.6	- 23 03	11.2	18 10.8	- 10 32	9.8	21 48.6	- 04 53	11.7
13	02 05.8	+ 10 02	11.9	22 52.7	- 15 31	11.8	01 20.6	+ 04 16	12.6	21 46.6	- 22 49	11.1	18 08.6	- 10 43	9.7	21 54.9	- 03 37	11.7
20	02 18.6	+ 11 07	11.9	23 03.4	- 14 43	11.8	01 34.5	+ 05 16	12.5	21 52.7	- 22 40	11.0	18 05.0	- 11 00	9.6	22 00.4	- 02 21	11.6
27	02 31.6	+ 12 09	11.9	23 13.6	- 13 57	11.7	01 48.5	+ 06 14	12.5	21 58.1	- 22 34	10.9	18 00.3	- 11 23	9.5	22 05.3	- 01 06	11.5
Jun 3	02 44.7	+ 13 07	11.8	23 23.3	- 13 14	11.6	02 02.6	+ 07 08	12.5	22 02.6	- 22 34	10.8	17 54.5	- 11 52	9.4	22 09.4	+ 00 09	11.4
10	02 57.9	+ 14 03	11.8	23 32.3	- 12 36	11.5	02 16.8	+ 07 59	12.5	22 06.1	- 22 39	10.7	17 48.1	- 12 26	9.3	22 12.7	+ 01 23	11.3
17	03 11.2	+ 14 55	11.8	23 40.8	- 12 01	11.4	02 31.1	+ 08 45	12.4	22 08.5	- 22 50	10.6	17 41.4	- 13 05	9.2	22 15.0	+ 02 35	11.2
24	03 24.5	+ 15 43	11.8	23 48.5	- 11 32	11.3	02 45.4	+ 09 28	12.4	22 09.9	- 23 06	10.5	17 34.7	- 13 47	9.3	22 16.4	+ 03 45	11.1
Jul 1	03 37.9	+ 16 28	11.8	23 55.3	- 11 09	11.2	02 59.8	+ 10 05	12.4	22 10.0	- 23 28	10.4	17 28.4	- 14 33	9.4	22 16.6	+ 04 51	11.0
8	03 51.3	+ 17 08	11.7	00 01.2	- 10 51	11.1	03 14.3	+ 10 37	12.3	22 08.9	- 23 55	10.2	17 22.9	- 15 20	9.6	22 15.8	+ 05 53	10.8
15	04 04.6	+ 17 44	11.7	00 06.1	- 10 40	10.9	03 28.7	+ 11 03	12.3	22 06.6	- 24 25	10.1	17 18.4	- 16 08	9.8	22 13.9	+ 06 48	10.7
22	04 18.0	+ 18 15	11.6	00 09.9	- 10 37	10.8	03 43.1	+ 11 24	12.2	22 03.1	- 24 58	10.0	17 15.1	- 16 56	9.9	22 10.8	+ 07 37	10.5
29	04 31.3	+ 18 42	11.6	00 12.3	- 10 40	10.7	03 57.3	+ 11 38	12.2	21 58.5	- 25 31	9.9	17 13.1	- 17 44	10.1	22 06.7	+ 08 18	10.4
Aug 5	04 44.4	+ 19 04	11.5	00 13.4	- 10 50	10.5	04 11.5	+ 11 45	12.1	21 53.1	- 26 02	9.8	17 12.4	- 18 30	10.2	22 01.8	+ 08 50	10.2
12	04 57.4	+ 19 22	11.5	00 13.1	- 11 06	10.3	04 25.3	+ 11 46	12.0	21 47.0	- 26 30	9.7	17 13.0	- 19 15	10.4	21 56.1	+ 09 11	10.1
19	05 10.2	+ 19 35	11.4	00 11.3	- 11 27	10.1	04 39.0	+ 11 40	12.0	21 40.8	- 26 51	9.7	17 14.9	- 19 59	10.5	21 50.0	+ 09 22	10.0
26	05 22.7	+ 19 43	11.3	00 08.1	- 11 51	10.0	04 52.2	+ 11 27	11.9	21 34.6	- 27 06	9.8	17 17.9	- 20 40	10.6	21 43.9	+ 09 22	10.0
Sep 2	05 34.9	+ 19 48	11.3	00 03.7	- 12 17	9.8	05 05.0	+ 11 07	11.8	21 28.9	- 27 12	9.9	17 22.1	- 21 19	10.8	21 38.0	+ 09 13	10.0
9	05 46.6	+ 19 48	11.2	23 58.3	- 12 41	9.6	05 17.2	+ 10 41	11.7	21 24.0	- 27 09	10.0	17 27.2	- 21 56	10.9	21 32.6	+ 08 56	10.1
16	05 57.8	+ 19 45	11.1	23 52.3	- 13 00	9.6	05 28.7	+ 10 09	11.6	21 20.1	- 26 58	10.1	17 33.3	- 22 30	11.0	21 28.2	+ 08 33	10.2
23	06 08.4	+ 19 39	11.0	23 46.1	- 13 13	9.6	05 39.5	+ 09 31	11.5	21 17.4	- 26 40	10.2	17 40.2	- 23 01	11.1	21 24.7	+ 08 07	10.3
30	06 18.3	+ 19 30	10.9	23 40.1	- 13 17	9.8	05 49.4	+ 08 47	11.4	21 16.0	- 26 14	10.3	17 47.8	- 23 30	11.2	21 22.5	+ 07 38	10.5
Oct 7	06 27.4	+ 19 19	10.8	23 34.9	- 13 11	10.0	05 58.2	+ 08 00	11.3	21 15.9	- 25 43	10.4	17 56.1	- 23 55	11.2	21 21.6	+ 07 10	10.6
14	06 35.6	+ 19 07	10.6	23 30.6	- 12 56	10.2	06 05.9	+ 07 09	11.2	21 17.2	- 25 06	10.6	18 05.0	- 24 16	11.3	21 22.1	+ 06 45	10.7
21	06 42.7	+ 18 55	10.5	23 27.7	- 12 30	10.3	06 12.3	+ 06 15	11.0	21 19.6	- 24 25	10.6	18 14.5	- 24 34	11.4	21 23.7	+ 06 22	10.8
28	06 48.5	+ 18 43	10.4	23 26.0	- 11 55	10.5	06 17.2	+ 05 22	10.9	21 23.1	- 23 40	10.7	18 24.3	- 24 49	11.4	21 26.6	+ 06 04	11.0
Nov 4	06 52.9	+ 18 32	10.2	23 25.9	- 11 12	10.7	06 20.5	+ 04 29	10.7	21 27.7	- 22 51	10.8	18 34.6	- 25 00	11.5	21 30.7	+ 05 51	11.1
11	06 55.9	+ 18 24	10.1	23 27.1	- 10 22	10.8	06 22.1	+ 03 40	10.6	21 33.2	- 21 59	10.9	18 45.2	- 25 07	11.5	21 35.7	+ 05 44	11.2
18	06 57.1	+ 18 19	9.9	23 29.6	- 09 25	11.0	06 22.0	+ 02 57	10.4	21 39.5	- 21 03	11.0	18 56.1	- 25 10	11.5	21 41.7	+ 05 43	11.2
25	06 56.6	+ 18 18	9.7	23 33.3	- 08 23	11.1	06 20.2	+ 02 22	10.3	21 46.5	- 20 05	11.0	19 07.3	- 25 10	11.5	21 48.6	+ 05 48	11.3
Dec 2	06 54.3	+ 18 22	9.6	23 38.1	- 07 17	11.3	06 16.8	+ 01 58	10.2	21 54.1	- 19 04	11.1	19 18.6	- 25 06	11.6	21 56.2	+ 05 59	11.4
9	06 50.3	+ 18 30	9.4	23 43.9	- 06 07	11.4	06 12.2	+ 01 47	10.0	22 02.3	- 18 00	11.1	19 30.1	- 24 58	11.6	22 04.5	+ 06 17	11.4
16	06 44.9	+ 18 43	9.2	23 50.5	- 04 53	11.5	06 06.6	+ 01 52	10.0	22 10.9	- 16 53	11.2	19 41.7	- 24 47	11.6	22 13.3	+ 06 40	11.5
23	06 38.3	+ 18 59	9.1	23 57.9	- 03 37	11.6	06 00.5	+ 02 12	9.9	22 19.9	- 15 45	11.2	19 53.3	- 24 32	11.5	22 22.7	+ 07 08	11.5
30	06 31.0	+ 19 19	9.0	00 06.0	- 02 18	11.7	05 54.6	+ 02 47	10.0	22 29.3	- 14 34	11.2	20 05.0	- 24 14	11.5	22 32.5	+ 07 42	11.5

COMETS FOR 2006

WHAT IS A COMET? It is a member of the Solar System, which is normally in a very eccentric orbit around the Sun. The orbits of periodic, or regularly reappearing comets, are quite eccentric or oval compared to those of the planets. Comets also differ from the planets by being far less massive, containing significant quantities of water in the form of ice and dust. A common analogy is a 'dirty snowball' (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, Encke, takes just over 3 years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of a number of new comets that have not been recorded before. The majority of these have either open-ended orbits (they are believed to be making their only visit to the Solar System and are not expected to return) or have extremely long orbital periods measured in thousands of years.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a *coma* around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionized particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of dust grains that trail behind the comet along the direction of its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails. In fact some may only show the coma.

Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' means the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 71P/Clark indicates 'Clark' was the 71st comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. The prefix of Halley's Comet is 1P/ because it was the first comet shown to be periodic. In fact Halley did not find the comet. It was named after him after he successfully predicted its return. You will also see references to another naming system, best explained with an example. You will notice one of the Comet LINEARs is referred to as 'C/2004 B1'. 2004 refers to the year, B is the 2nd half-month period ('I' is not used) during the year and 1 shows it was the 1st discovery in this half month. Therefore C/2004 B1 (LINEAR) was the 1st comet discovered in the 2nd half of January 2004.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbit, overall brightness, size of the coma and tail can vary dramatically from comet to comet and even from return to return. To watch one brighten, develop a tail and then fade away over a period of a few weeks, can be a fascinating experience.

This section is devoted to the comets that are expected to be observable during 2006. The table (opposite) lists these objects as well as their orbital elements. This is the data required to calculate their locations in the sky. It lists all the known comets expected to be visible that reach perihelion (closest approach to the Sun) during 2006. There is also one included that may be visible during 2006 but has a perihelion date in 2004. The elements are followed by 'ephemerides' (a list of expected positions in the sky and magnitude estimates for different dates) for some of the brighter comets. These positions can be plotted on the All Sky Maps to get an idea of where they are in the sky. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could have it too close to the Sun or on the opposite side of the Sun from Earth. This would likely be considered unfavourable.

Many of the comets expected in 2006 are extremely faint and would require professional-size telescopes or long exposure photographs/images to detect them, but who knows what could be discovered tomorrow?

NOTES ON SELECTED COMETS FOR 2006 – *by Greg Bryant*

Comet 73P/Schwassmann-Wachmann 3: Barring any new discoveries that occur after this book has been published, comet 73P/Schwassmann-Wachmann 3 is predicted to be the highlight comet of 2006, possibly brightening to 2nd magnitude in May.

Arnold Schwassmann and Arno Arthur Wachmann, of Hamburg Observatory in Germany, discovered this comet on photographic plates taken on 2nd May 1930. By the end of May it brightened to 6th magnitude as it passed just 0.06 AU from Earth. It was recognised to be of short period, but uncertainties in its orbit meant that the comet became lost afterwards. In 1979, astronomers at Perth Observatory discovered a comet, which was recognised to be the return of Schwassmann-Wachmann 3.

Being a relatively faint comet, little was expected for its 1995 return, however in September and October many observers saw the comet brighter than 6th magnitude, with a dust tail in excess of one degree in length. At this time, the comet was nearly seven magnitudes brighter than predicted, and observations made at the European Southern Observatory in Chile revealed that the comet had split into several pieces.

At the comet's return in 2001, two of the fragments were still many magnitudes brighter than normal (a third appeared to dissipate during the apparition). The forecasts for this comet's showing in 2006 are based on its light curve in 2001. The bright prospects are based on the comet's predicted close approach to Earth in May, nearly surpassing that of its discovery apparition in 1930. There's always the chance that the two fragments may have declined in brightness, or even crumbled away, by the time they are recovered (which should occur by the end of 2005).

Comet 4P/Faye: Herve Faye (Royal Observatory, Paris) discovered this comet on November 23rd, 1843. Around 6th magnitude in brightness, it was followed for nearly four months and it was quickly realised that it was a short-period comet. Its recovery in 1850, ahead of its perihelion passage the following year, made it only the 4th comet at the time to have been seen at two returns – hence the appellation '4P'. This will be the 21st observed apparition of comet Faye and it is expected to peak at around 10th magnitude in late Spring.

Comet 29P/Schwassmann-Wachmann 1: Arnold Schwassmann and Arno Arthur Wachmann (see above) discovered this comet on images taken on 15th November 1927. Of all the periodic comets, SW 1 is perhaps the most unusual. It has a near-circular orbit and lies beyond Jupiter. Virtually every year, it experiences at least one outburst in brightness, from its norm of 18th magnitude to 13th magnitude, and sometimes as bright as 10th magnitude. During 2004, it remained as bright as 13th magnitude for virtually the entire year, intriguing observers as to whether it marked a distinct change in the comet's character.

Comet 41P/Tuttle-Giacobini-Kresak: The American comet hunter Horace Tuttle discovered this comet on May 3rd, 1858. Astronomers calculated that the comet was periodic, although estimates of the comet's period ranged from 5.8 to 7.5 years. On June 1st, 1907, Michel Giacobini came across a 13th magnitude comet. A parabolic orbit was assumed, but in 1914, it was suggested that the comet might be related to Tuttle's comet of 1858, and Crommelin mathematically linked the two in 1928. On April 24th, 1951, Lubor Kresak discovered a 10th magnitude comet which was well placed for observation and it was soon identified as a recovery of the lost Comet Tuttle-Giacobini. Kresak's name was added to the comet.

In 1973, the comet surprised everyone. On May 20th, ten days before perihelion, it was estimated at 13th magnitude. Six days later, S. Ako of Japan photographed an "unknown" comet of 8th magnitude, and the following day another Japanese astronomer independently detected the comet at 5th magnitude. The comet was actually Tuttle-Giacobini-Kresak undergoing a major outburst, and a photo of the comet later that day saw it at around 4th magnitude. Tuttle-Giacobini-Kresak's outburst declined

after a few days, but in the first week of July, it jumped again from 14th to 5th magnitude. Since then, the comet has been relatively well behaved, although in August 1995, the comet did undergo a small outburst in brightness to 9th magnitude.

This year's return of Tuttle-Giacobini-Kresak sees the comet pass 0.94 AU from Earth, its closest passage since 1973. In two returns time, in 2017, the comet will pass just 0.14 AU from Earth, the closest approach it has experienced since it was discovered. At that apparition, the comet is predicted to reach 7th magnitude – let's hope there's another huge outburst!

Comet 71P/Clark: During the course of a variable star photographic patrol at Mount John University Observatory in New Zealand, Michael Clark discovered this comet on June 9th, 1973. This 13th magnitude object was confirmed as a short-period comet, returning to perihelion every 5.5 years. The orbit is such that apparitions of this comet oscillate between favourable and unfavourable returns. The last favourable return of comet Clark was in 1995. In 2006, comet Clark is expected to brighten to 11th magnitude by mid-year. This year's return sees Clark's closest recorded approach to Earth – 0.59 AU. Further returns will see the comet's perihelion passage move further out, and by the mid-21st century, it will not pass any closer to the Sun than just under 2 AU.

Comet P/1991 V1 (Shoemaker-Levy 6): The comet-hunting team of Carolyn and Eugene Shoemaker and David Levy discovered this comet on an image taken with the 0.46m Schmidt telescope at Palomar on 7th November 1991. Further observations revealed that this new comet was of short period, orbiting the Sun every 7.5 years and passing perihelion at a distance of 1.1 AU. It was expected to return in 1999, but it passed undetected. Admittedly, the observing prospects for that return were extremely poor. The 2006 return should see it recovered, though it is not quite as favourable as that of its 1991 discovery passage. The first visual observations should occur in November 2006 when the comet is predicted to be 13th magnitude in the evening sky.

Comet C/2004 B1 (LINEAR): On 29th January 2004, the Lincoln Near Earth Asteroid Research (LINEAR) programme in New Mexico detected an asteroidal object with an initial orbit unusual enough to warrant being flagged on the Minor Planet Centre's NEO (Near Earth Object) Confirmation Page. Canadian amateur astronomer Bill Yeung imaged the apparent asteroid and his observations revealed the object to actually be a comet — LINEAR's 132nd comet (as at the time of writing, August 2005, LINEAR has discovered 158 comets in total).

Discovered some two years out from perihelion, which occurs in 2006 on February 7th at 1.6 AU from the Sun, comet LINEAR may brighten to 10th magnitude in autumn 2006 when it will be best observed in the morning sky. Prior to that, in late 2005, LINEAR will pass within four degrees of the south celestial pole in early November. LINEAR's passage through the inner Solar System is a relatively distant apparition, never coming closer than 1.3 AU to Earth.

BIOGRAPHICAL NOTE – Greg Bryant *is an Associate Editor for Australian Sky & Telescope magazine and can be reached at* greg@austskyandtel.com.au

COMETS FOR 2006 – ORBITAL ELEMENTS (Equinox 2000.0)

Comet Name	Perihelion Date yyyy mm dd.dddd	q AU	e	Period years	ω °	Ω °	Incl. °	H1	K1
29P/Schwassmann-Wachmann 1	2004 07 03.5881	5.722966	0.044075	14.6	48.4447	312.6935	9.3904	4.0	7.5
C/2002 VQ94 (LINEAR)	2006 02 06.6569	6.796717	0.966856		100.0364	35.0164	70.5154	6.0	7.5
C/2004 B1 (LINEAR)	2006 02 07.8904	1.601934	1.001299		327.9003	272.8023	114.0976	7.0	7.5
C/2004 D1 (NEAT)	2006 02 10.8131	4.974519	1.001438		75.5415	62.2540	45.5404	8.0	7.5
132P/Helin-Roman-Alu 2	2006 02 14.9934	1.924163	0.529995	8.3	221.0984	178.3877	5.7659	10.0	20.0
C/2005 E2 (McNaught)	2006 02 23.5436	1.520239	0.999941		39.9509	347.8549	16.9875	7.0	7.5
C/2005 B1 (Christensen)	2006 02 23.5700	3.204925	1.000342		103.1833	195.5565	92.5516	8.5	7.5
C/2005 G1 (LINEAR)	2006 02 27.3198	4.960935	1.000022		113.8176	299.5870	108.4143	10.0	7.5
98P/Takamizawa	2006 03 06.4762	1.662810	0.562105	7.4	157.8784	114.7656	10.5567	9.0	20.0
83P/Russell 1	2006 04 08.8411	2.172631	0.438795	7.6	333.7643	226.4222	17.7747	14.0	15.0
C/2003 WT42 (LINEAR)	2006 04 10.7694	5.191114	1.002489		92.4650	48.4537	31.4104	5.0	7.5
P/1999 RO28 (LONEOS)	2006 05 13.5620	1.227791	0.651464	6.6	219.9672	148.3708	8.1851	20.5	10.0
71P/Clark	2006 06 07.2131	1.562127	0.499855	5.5	208.7515	59.6553	9.4886	8.0	20.0
102P/Shoemaker 1	2006 06 07.3313	1.973642	0.472263	7.2	18.5591	339.9444	26.2531	3.5	30.0
73P/Schwassmann-Wachmann 3-C	2006 06 07.3766	0.939164	0.693257	5.4	198.8088	69.8941	11.3971	8.0	17.0
73P/Schwassmann-Wachmann 3-B	2006 06 08.1826	0.939192	0.693310	5.4	198.8088	69.8895	11.3979	11.5	15.0
41P/Tuttle-Giacobini-Kresak	2006 06 11.2754	1.047778	0.660357	5.4	62.1972	141.0898	9.2295	10.0	40.0
45P/Honda-Mrkos-Pajdusakova	2006 06 29.7850	0.530249	0.284500	5.3	326.1168	89.1103	4.2532	13.5	20.0
P/1999 X1 (Hug-Bell)	2006 07 06.6805	1.947003	0.470981	7.1	296.8745	103.6482	10.9630	13.5	10.0
84P/Giclas	2006 08 07.4552	1.851739	0.492412	7.0	276.3267	112.4745	7.2809	11.5	10.0
52P/Harrington-Abell	2006 08 14.7749	1.757114	0.542855	7.5	139.0847	337.1779	10.2205	13.0	10.0
114P/Wiseman-Skiff	2006 09 13.2046	1.577590	0.555098	6.7	172.8998	271.0433	18.2655	11.0	15.0
80P/Peters-Hartley	2006 09 25.8202	1.633650	0.596153	8.1	338.6093	259.8816	29.8963	7.0	25.0
112P/Urata-Niijima	2006 10 29.5759	1.464693	0.586488	6.7	21.4481	31.9281	24.1675	15.0	10.0
P/2000 C1 (Hergenrother)	2006 11 06.9189	2.088289	0.407732	6.6	51.2961	127.0066	6.1081	12.0	12.0
4P/Faye	2006 11 15.4542	1.667350	0.566691	7.6	205.0158	199.3081	9.0316	7.0	17.0
P/1991 V1 (Shoemaker-Levy 6)	2006 11 17.0174	1.128084	0.706258	7.5	333.5406	37.8763	16.9224	13.0	10.0
76P/West-Kohoutek-Ikemura)	2006 11 19.6466	1.603425	0.538471	6.5	0.1265	84.1074	30.4585	8.5	30.0
P/2000 R2 (LINEAR)	2006 12 14.4648	1.454266	0.565466	6.1	172.2141	163.1448	10.9663	18.5	10.0

Perihelion Date Date of closest approach to the Sun.

q The perihelion distance, in AU (Astronomical Units)

e The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to or greater than one indicates: an open orbit (a once only visitor to the Solar System), it has a very long period (thousands of years) or it is newly discovered and astronomers have not clearly defined its orbit.

Period The comet's period in years. The time taken for one orbit of the Sun.

ω Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).

Ω Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (Ecliptic) as the comet moves north.

i Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. A value greater than 90° means the comet's orbit direction is retrograde (moves in the opposite direction to the planets).

H1 The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it was one AU from the Sun and the Earth.

K1 A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' for further details)

Calculation of ephemerides from these elements is complex (but not difficult, with the power of home computers) but beyond the scope of this book.

Comet 71P/Clark

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2006 Mar 25	17 17.1	-19 39	1.173	1.716	104	13.0
2006 Apr 1	17 32.2	-20 35	1.095	1.690	108	12.8
2006 Apr 8	17 47.2	-21 34	1.021	1.666	111	12.5
2006 Apr 15	18 01.8	-22 35	0.953	1.644	114	12.2
2006 Apr 22	18 16.1	-23 40	0.890	1.625	118	12.0
2006 Apr 29	18 29.8	-24 51	0.831	1.608	122	11.7
2006 May 6	18 42.8	-26 08	0.779	1.593	126	11.5
2006 May 13	18 54.8	-27 34	0.732	1.581	130	11.3
2006 May 20	19 05.7	-29 07	0.690	1.572	134	11.1
2006 May 27	19 15.1	-30 48	0.656	1.566	139	11.0
2006 Jun 3	19 23.0	-32 36	0.627	1.563	143	10.9
2006 Jun 10	19 29.0	-34 27	0.606	1.562	148	10.8
2006 Jun 17	19 33.2	-36 18	0.592	1.565	153	10.8
2006 Jun 24	19 35.6	-38 03	0.585	1.571	157	10.8
2006 Jul 1	19 36.3	-39 36	0.586	1.579	160	10.8
2006 Jul 8	19 35.9	-40 51	0.595	1.590	161	10.9
2006 Jul 15	19 34.9	-41 46	0.612	1.604	160	11.0
2006 Jul 22	19 33.9	-42 17	0.636	1.621	157	11.2
2006 Jul 29	19 33.6	-42 26	0.668	1.640	153	11.4
2006 Aug 5	19 34.5	-42 14	0.708	1.661	149	11.7
2006 Aug 12	19 36.8	-41 44	0.754	1.685	145	11.9
2006 Aug 19	19 40.7	-41 00	0.807	1.710	140	12.2
2006 Aug 26	19 45.9	-40 05	0.868	1.738	135	12.5
2006 Sep 2	19 52.6	-39 01	0.934	1.767	131	12.8

Comet 73P/Schwassmann-Wachmann 3-B

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2006 Mar 18	14 11.8	+16 53	0.553	1.469	142	12.7
2006 Mar 25	14 19.8	+18 42	0.472	1.404	143	12.1
2006 Apr 1	14 28.2	+20 48	0.397	1.339	144	11.4
2006 Apr 8	14 37.6	+23 12	0.327	1.276	142	10.7
2006 Apr 15	14 49.7	+26 00	0.263	1.216	140	9.9
2006 Apr 22	15 07.6	+29 26	0.203	1.158	135	9.0
2006 Apr 29	15 39.6	+33 59	0.147	1.104	129	8.0
2006 May 6	16 52.9	+40 10	0.097	1.056	117	6.8
2006 May 13	20 04.7	+39 56	0.066	1.014	92	5.7
2006 May 20	23 15.0	+15 44	0.078	0.981	64	5.8
2006 May 27	00 29.3	+00 01	0.121	0.956	59	6.6
2006 Jun 3	01 03.7	-06 39	0.173	0.942	61	7.3
2006 Jun 10	01 24.8	-09 44	0.228	0.940	64	7.9
2006 Jun 17	01 40.3	-11 14	0.282	0.948	68	8.4
2006 Jun 24	01 52.7	-11 58	0.333	0.968	72	8.9
2006 Jul 1	02 03.1	-12 19	0.381	0.997	76	9.4
2006 Jul 8	02 11.6	-12 32	0.424	1.035	81	9.9
2006 Jul 15	02 18.3	-12 44	0.461	1.080	85	10.3
2006 Jul 22	02 23.1	-13 01	0.494	1.132	90	10.8
2006 Jul 29	02 25.7	-13 24	0.522	1.187	96	11.2
2006 Aug 5	02 25.9	-13 55	0.546	1.247	102	11.6
2006 Aug 12	02 23.5	-14 34	0.567	1.309	109	12.0
2006 Aug 19	02 18.5	-15 17	0.587	1.372	116	12.4
2006 Aug 26	02 10.8	-16 03	0.608	1.437	123	12.8

Comet 41P/Tuttle-Giacobini-Kresak

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2006 May 6	07 30.6	+25 23	1.129	1.156	65	12.8
2006 May 13	07 54.3	+25 27	1.106	1.120	64	12.2
2006 May 20	08 19.9	+25 14	1.080	1.091	63	11.7
2006 May 27	08 47.2	+24 41	1.052	1.068	62	11.3
2006 Jun 3	09 16.2	+23 45	1.024	1.054	62	11.0
2006 Jun 10	09 46.5	+22 22	0.998	1.048	63	10.8
2006 Jun 17	10 17.9	+20 32	0.975	1.051	64	10.8
2006 Jun 24	10 50.2	+18 14	0.956	1.062	65	10.9
2006 Jul 1	11 22.8	+15 28	0.945	1.082	67	11.2
2006 Jul 8	11 55.6	+12 20	0.943	1.109	69	11.7
2006 Jul 15	12 28.1	+08 54	0.950	1.142	71	12.2
2006 Jul 22	13 00.0	+05 19	0.969	1.182	73	12.8

Comet 73P/Schwassmann-Wachmann 3-C

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2006 Feb 4	13 22.8	+10 51	1.172	1.856	119	12.9
2006 Feb 11	13 32.3	+11 14	1.052	1.791	123	12.4
2006 Feb 18	13 41.5	+11 49	0.939	1.726	127	11.9
2006 Feb 25	13 50.6	+12 36	0.832	1.660	131	11.3
2006 Mar 4	13 59.5	+13 36	0.731	1.593	135	10.8
2006 Mar 11	14 08.3	+14 49	0.636	1.527	138	10.1
2006 Mar 18	14 17.2	+16 18	0.549	1.461	141	9.5
2006 Mar 25	14 26.4	+18 01	0.467	1.396	142	8.8
2006 Apr 1	14 36.4	+20 01	0.392	1.332	143	8.1
2006 Apr 8	14 48.1	+22 18	0.322	1.269	142	7.3
2006 Apr 15	15 03.6	+24 58	0.257	1.209	139	6.5
2006 Apr 22	15 27.0	+28 10	0.197	1.152	134	5.5
2006 Apr 29	16 09.2	+32 12	0.142	1.099	127	4.5
2006 May 6	17 41.6	+36 15	0.096	1.051	114	3.3
2006 May 13	20 46.4	+29 42	0.074	1.010	88	2.4
2006 May 20	23 15.5	+09 42	0.093	0.977	66	2.7
2006 May 27	00 22.7	-01 55	0.138	0.954	61	3.4
2006 Jun 3	00 57.6	-07 12	0.191	0.941	63	4.0
2006 Jun 10	01 20.0	-09 44	0.246	0.940	65	4.5
2006 Jun 17	01 36.6	-10 58	0.300	0.950	69	5.0
2006 Jun 24	01 50.0	-11 33	0.351	0.971	73	5.5
2006 Jul 1	02 01.1	-11 50	0.398	1.001	76	6.0
2006 Jul 8	02 10.2	-11 60	0.441	1.040	81	6.5
2006 Jul 15	02 17.4	-12 10	0.478	1.086	85	7.0
2006 Jul 22	02 22.6	-12 25	0.510	1.138	90	7.5
2006 Jul 29	02 25.6	-12 47	0.537	1.194	96	8.0
2006 Aug 5	02 26.2	-13 17	0.560	1.254	102	8.4
2006 Aug 12	02 24.2	-13 55	0.581	1.316	108	8.8
2006 Aug 19	02 19.5	-14 38	0.600	1.380	115	9.3
2006 Aug 26	02 12.2	-15 24	0.620	1.445	123	9.7
2006 Sep 2	02 02.3	-16 07	0.644	1.511	131	10.1
2006 Sep 9	01 50.6	-16 43	0.672	1.577	139	10.5
2006 Sep 16	01 37.5	-17 06	0.708	1.643	147	10.9
2006 Sep 23	01 24.0	-17 14	0.753	1.709	153	11.3
2006 Sep 30	01 10.9	-17 04	0.808	1.775	157	11.8
2006 Oct 7	00 59.1	-16 37	0.875	1.840	158	12.2
2006 Oct 14	00 49.0	-15 56	0.952	1.904	155	12.6

Hale-Bopp on 8 April 1997 from the VLA, New Mexico. Six minutes on Kodak Royal 1000, 135mm f2.8 lens.

C/2004 B1 (LINEAR)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2005 Nov 5	02 16.0	-86 22	2.000	2.039	78	10.8
2005 Nov 12	21 38.7	-83 58	2.029	1.985	73	10.8
2005 Nov 19	20 36.4	-78 57	2.071	1.933	68	10.7
2005 Nov 26	20 18.6	-73 58	2.122	1.883	63	10.7
2005 Dec 3	20 12.6	-69 17	2.177	1.837	57	10.7
2005 Dec 10	20 11.1	-64 57	2.234	1.794	51	10.6
2005 Dec 17	20 11.8	-60 58	2.290	1.754	46	10.6
2005 Dec 24	20 13.6	-57 18	2.341	1.718	41	10.6
2005 Dec 31	20 16.0	-53 54	2.385	1.686	36	10.6
2006 Jan 7	20 18.6	-50 44	2.420	1.659	31	10.6
2006 Jan 14	20 21.3	-47 46	2.445	1.637	28	10.5
2006 Jan 21	20 23.9	-44 58	2.457	1.620	25	10.5
2006 Jan 28	20 26.3	-42 17	2.456	1.609	24	10.5
2006 Feb 4	20 28.5	-39 42	2.441	1.603	25	10.5
2006 Feb 11	20 30.3	-37 10	2.412	1.602	27	10.4
2006 Feb 18	20 31.7	-34 39	2.370	1.608	31	10.4
2006 Feb 25	20 32.5	-32 07	2.314	1.619	36	10.4
2006 Mar 4	20 32.7	-29 33	2.246	1.635	41	10.4
2006 Mar 11	20 32.0	-26 54	2.166	1.657	47	10.3
2006 Mar 18	20 30.4	-24 06	2.076	1.683	53	10.3
2006 Mar 25	20 27.7	-21 08	1.978	1.714	60	10.2
2006 Apr 1	20 23.5	-17 55	1.875	1.749	67	10.2
2006 Apr 8	20 17.5	-14 23	1.770	1.789	75	10.1
2006 Apr 15	20 09.5	-10 29	1.666	1.832	83	10.1
2006 Apr 22	19 58.9	-06 09	1.568	1.878	91	10.0
2006 Apr 29	19 45.4	-01 20	1.481	1.927	100	10.0
2006 May 6	19 28.5	+03 53	1.411	1.979	109	10.0
2006 May 13	19 08.0	+09 23	1.364	2.033	117	10.0
2006 May 20	18 44.1	+14 50	1.345	2.089	124	10.0
2006 May 27	18 17.4	+19 53	1.358	2.146	129	10.2
2006 Jun 3	17 49.2	+24 09	1.404	2.206	131	10.3
2006 Jun 10	17 21.2	+27 23	1.480	2.266	130	10.5
2006 Jun 17	16 55.0	+29 37	1.582	2.328	126	10.7
2006 Jun 24	16 31.9	+30 56	1.706	2.391	121	11.0
2006 Jul 1	16 12.4	+31 33	1.845	2.455	115	11.3
2006 Jul 8	15 56.6	+31 40	1.996	2.519	109	11.5
2006 Jul 15	15 44.2	+31 27	2.156	2.584	103	11.8
2006 Jul 22	15 34.8	+31 02	2.320	2.650	97	12.0
2006 Jul 29	15 28.0	+30 29	2.486	2.716	92	12.2
2006 Aug 5	15 23.3	+29 53	2.652	2.782	87	12.5
2006 Aug 12	15 20.4	+29 15	2.817	2.849	82	12.7
2006 Aug 19	15 19.0	+28 38	2.978	2.916	77	12.9
2006 Aug 26	15 18.8	+28 03	3.135	2.983	72	13.0

EXPLANATION OF COMET EPHEMERIDES

Date is for 0 hr UT (10am EST, 9:30am CST and 8am WST) of date.

R.A., Dec Right Ascension and Declination are for equinox 2000.0

Δ (delta) Geocentric distance (distance from the Earth) in AU.

R Heliocentric distance (distance from the Sun) in AU.

Elg Elongation; angular distance of the comet from the Sun.

Mag This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is invariably based on the behaviour of its brightness during previous return(s).

The estimate of total magnitude is normally calculated using the formula:

$$\text{Mag.} = H1 + 5 \log(\Delta) + K1 \log R.$$

See the table of elements for the values of H1 and K1. For many comets the K1 value is equal to 10. For newly discovered comets the value of K1 is mostly assumed to be equal to 10 until its light curve can be studied in detail. The brightness of a comet is often very uncertain, especially for those newly discovered. In fact, it is now believed that comets making their first visit to the Sun have an average K value of approximately 7.5. Comets have also been known to suddenly flare up or fade away and some have even shown a different behaviour in their light curve (changed values for H1 and K1) after perihelion compared to before. There are also constants of H2 and K2 used by astronomers which refer to the absolute magnitude and the K constant for the nucleus of the comet. These are not used in this publication.

Comet C/2005 E2 (McNaught)

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2005 Nov 5	20 03.1	-27 29	2.163	2.129	75	11.1
2005 Nov 12	20 13.5	-26 00	2.179	2.068	70	11.1
2005 Nov 19	20 24.9	-24 26	2.193	2.007	66	11.0
2005 Nov 26	20 37.2	-22 46	2.204	1.949	62	10.9
2005 Dec 3	20 50.4	-20 59	2.212	1.893	59	10.8
2005 Dec 10	21 04.3	-19 05	2.218	1.839	55	10.7
2005 Dec 17	21 18.9	-17 03	2.221	1.789	52	10.6
2005 Dec 24	21 34.1	-14 53	2.223	1.741	49	10.5
2005 Dec 31	21 49.9	-12 34	2.224	1.697	46	10.5
2006 Jan 7	22 06.3	-10 08	2.224	1.657	44	10.4
2006 Jan 14	22 23.3	-07 33	2.224	1.621	41	10.3
2006 Jan 21	22 40.7	-04 52	2.225	1.590	39	10.2
2006 Jan 28	22 58.7	-02 04	2.227	1.565	37	10.2
2006 Feb 4	23 17.1	+00 50	2.232	1.544	36	10.2
2006 Feb 11	23 36.1	+03 47	2.239	1.530	34	10.1
2006 Feb 18	23 55.6	+06 46	2.250	1.522	33	10.1
2006 Feb 25	00 15.6	+09 45	2.265	1.520	32	10.1
2006 Mar 4	00 36.1	+12 42	2.285	1.525	31	10.2
2006 Mar 11	00 57.1	+15 34	2.311	1.535	30	10.2
2006 Mar 18	01 18.6	+18 19	2.342	1.552	29	10.3
2006 Mar 25	01 40.6	+20 55	2.378	1.574	28	10.4
2006 Apr 1	02 03.0	+23 21	2.421	1.602	28	10.5
2006 Apr 8	02 25.8	+25 34	2.469	1.635	27	10.6
2006 Apr 15	02 48.8	+27 32	2.522	1.673	26	10.7
2006 Apr 22	03 12.0	+29 16	2.579	1.715	24	10.8
2006 Apr 29	03 35.1	+30 45	2.641	1.760	23	11.0
2006 May 6	03 58.2	+31 59	2.707	1.809	22	11.1
2006 May 13	04 20.9	+32 57	2.776	1.861	20	11.2
2006 May 20	04 43.3	+33 41	2.846	1.916	19	11.4
2006 May 27	05 05.1	+34 12	2.918	1.973	17	11.5
2006 Jun 3	05 26.4	+34 30	2.991	2.032	16	11.7
2006 Jun 10	05 46.9	+34 37	3.064	2.093	14	11.8
2006 Jun 17	06 06.6	+34 35	3.135	2.155	13	12.0
2006 Jun 24	06 25.5	+34 24	3.205	2.219	12	12.1
2006 Jul 1	06 43.6	+34 06	3.273	2.283	11	12.3
2006 Jul 8	07 00.9	+33 41	3.337	2.349	11	12.4
2006 Jul 15	07 17.3	+33 12	3.398	2.415	12	12.5
2006 Jul 22	07 32.9	+32 39	3.455	2.482	14	12.7
2006 Jul 29	07 47.7	+32 02	3.507	2.550	17	12.8
2006 Aug 5	08 01.7	+31 24	3.553	2.618	19	12.9
2006 Aug 12	08 14.9	+30 44	3.593	2.686	23	13.0

Comet 4P/Faye

Date	R.A. h m	Dec ° '	Δ AU	R AU	Elg °	Mag
2006 Jul 29	00 58.0	+13 06	1.426	1.979	107	12.8
2006 Aug 5	01 08.2	+13 52	1.332	1.945	111	12.5
2006 Aug 12	01 17.9	+14 29	1.243	1.912	116	12.3
2006 Aug 19	01 27.2	+14 57	1.158	1.881	120	12.0
2006 Aug 26	01 35.9	+15 14	1.079	1.851	125	11.7
2006 Sep 2	01 43.8	+15 18	1.005	1.823	130	11.4
2006 Sep 9	01 50.8	+15 08	0.938	1.796	135	11.2
2006 Sep 16	01 56.7	+14 43	0.877	1.772	141	10.9
2006 Sep 23	02 01.5	+14 00	0.823	1.750	147	10.7
2006 Sep 30	02 05.0	+13 02	0.777	1.731	153	10.5
2006 Oct 7	02 07.4	+11 48	0.740	1.713	160	10.3
2006 Oct 14	02 08.7	+10 22	0.712	1.699	167	10.2
2006 Oct 21	02 09.1	+08 47	0.694	1.687	173	10.1
2006 Oct 28	02 09.1	+07 11	0.686	1.678	174	10.0
2006 Nov 4	02 09.1	+05 40	0.688	1.671	168	10.0
2006 Nov 11	02 09.6	+04 20	0.699	1.668	162	10.0
2006 Nov 18	02 10.8	+03 17	0.720	1.668	155	10.1
2006 Nov 25	02 13.1	+02 32	0.749	1.670	148	10.2
2006 Dec 2	02 16.7	+02 08	0.786	1.676	142	10.3
2006 Dec 9	02 21.7	+02 02	0.830	1.684	136	10.4
2006 Dec 16	02 27.9	+02 14	0.881	1.695	131	10.6
2006 Dec 23	02 35.4	+02 41	0.938	1.709	126	10.8
2006 Dec 30	02 44.0	+03 20	1.001	1.726	121	11.0

METEOR SHOWERS

What is a meteor shower?

A meteor shower is no more than the leftover debris from a comet. A comet has been best described as a 'dirty snowball', a conglomerate of ice, gas, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun. These particles are then pushed away by solar radiation or solar wind to form the classical dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical-shaped donut. The effects of solar radiation and the slight gravity tugs from the planets will, over time, break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical visual meteor may be as small as a grain of sand, up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid meteors, at 71 km/s, are the fastest of the showers.

Incredible velocities such as these (a bullet from a rifle travels at about 1 km per second) result in the meteor's kinetic energy being converted to heat when it strikes the atmosphere at an altitude of about 100 km. The surrounding air is heated to incandescence by friction and as a consequence we can observe these tiny bodies as they self-destruct in our atmosphere.

Individual meteors during a shower appear to originate from a common point in the sky, known as the radiant. This focal point is named after the constellation in which the meteors appear or the comet that is associated with the shower. Individual particles of meteoroid streams travel though space in parallel paths. The apparent divergence from the radiant is only an illusion, due simply to the effect of perspective. The way that trees and buildings converge on either side of a long straight road is the same effect that is seen when a meteor shower occurs far above an observer.

The table of Meteor Showers has been compiled from the Meteor Shower Calendar produced by the International Meteor Organisation (IMO). It is the most accurate listing for naked-eye meteor observing available today. The table is complete in that both northern and southern showers are listed. Serious meteor observing should be carried out under dark skies, and preferably without the Moon. The best showers for this year, taking into consideration the lunar phase, are summarised in the monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic meteors (originating from random points in the sky) are visible per hour under dark sky conditions. More meteors are seen in the morning sky than in the evening; as the morning sky is facing the Earth's motion in space we tend to 'run into' and 'sweep up' meteors, whereas evening meteors must have sufficient velocity to catch up to the speeding Earth. Amateurs wishing to follow up an interest in meteors, and even make a contribution to meteor science, should contact the International Meteor Organisation (www.imo.net/).

SHOWER	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		DIA	VEL km/s	ZHR
				R.A.	Dec			
Quadrantids	FQ	Jan 01 – Jan 05	Jan 03	230˚	+49˚	5˚	41	120
delta-Cancrids	FM	Jan 01 – Jan 24	Jan 17	130˚	+20˚	10˚ – 5˚	28	4
alpha-Centaurids	FQ	Jan 28 – Feb 21	Feb 08	210˚	–59˚	4˚	56	6
delta-Leonids	NM	Feb 15 – Mar 10	Feb 24	168˚	+16˚	5˚	23	2
gamma-Normids	FM	Feb 25 – Mar 22	Mar 13	249˚	–51˚	5˚	56	8
Virginids	LQ	Jan 25 – Apr 15	Mar 24	195˚	–04˚	15˚ – 10˚	30	5
Lyrids	LQ	Apr 16 – Apr 25	Apr 22	271˚	+34˚	5˚	49	18
pi-Puppids*	LQ	Apr 15 – Apr 28	Apr 23	110˚	–45˚	5˚	18	var
eta-Aquarids	FQ	Apr 19 – May 28	May 05	338˚	–01˚	4˚	66	60
Sagittarids	LQ	Apr 15 – Jul 15	May 20	247˚	–22˚	15˚ – 10˚	30	5
Bootids (June)*	NM	Jun 26 – Jul 02	Jun 27	224˚	+48˚	5˚	18	var
Pegasids	FM	Jul 07 – Jul 13	Jul 09	340˚	+15˚	5˚	70	3
Phoenicids (July)*	FM	Jul 10 – Jul 16	Jul 13	032˚	–48˚	7˚	47	var
Pisces Austrinids	NM	Jul 15 – Aug 10	Jul 28	341˚	–30˚	15˚ – 10˚	35	5
Southern delta-Aquarids	NM	Jul 12 – Aug 19	Jul 28	339˚	–16˚	5˚	41	20
alpha-Capricornids	FQ	Jul 03 – Aug 15	Jul 30	307˚	–10˚	8˚	23	4
Southern iota-Aquarids	FQ	Jul 25 – Aug 15	Aug 04	334˚	–15˚	5˚	34	2
Northern delta-Aquarids	FM	Jul 15 – Aug 25	Aug 08	335˚	–05˚	5˚	42	4
Perseids	FM	Jul 17 – Aug 24	Aug 12	046˚	+58˚	5˚	59	100
kappa-Cygnids	LQ	Aug 03 – Aug 25	Aug 18	286˚	+59˚	6˚	25	3
Northern iota-Aquarids	LQ	Aug 11 – Aug 31	Aug 20	327˚	–06˚	5˚	31	3
alpha-Aurigids	FQ	Aug 25 – Sep 08	Sep 01	084˚	+42˚	5˚	66	7
delta-Aurigids	FM	Sep 05 – Oct 10	Sep 09	060˚	+47˚	5˚	64	5
Piscids	NM	Sep 01 – Sep 30	Sep 20	005˚	–01˚	5˚	26	3
Draconids*	FM	Oct 06 – Oct 10	Oct 08	262˚	+54˚	2˚	20	var
Epsilon Geminids	LQ	Oct 14 – Oct 27	Oct 18	102˚	+27˚	5˚	70	2
Orionids	NM	Oct 02 – Nov 07	Oct 21	095˚	+16˚	10˚	66	23
Southern Taurids	FM	Oct 01 – Nov 25	Nov 05	052˚	+13˚	10˚ – 5˚	27	5
Northern Taurids	LQ	Oct 01 – Nov 25	Nov 12	058˚	+22˚	10˚ – 5˚	29	5
Leonids	NM	Nov 14 – Nov 21	Nov 19	153˚	+22˚	5˚	71	100+
alpha-Monocerotids	NM	Nov 15 – Nov 25	Nov 21	117˚	+01˚	5˚	65	Var
chi-Orionids	FQ	Nov 26 – Dec 15	Dec 02	082˚	+23˚	8˚	28	3
Phoenicids	FM	Nov 28 – Dec 09	Dec 06	018˚	–53˚	5˚	22	Var
Puppid-Velids	FM	Dec 01 – Dec 15	Dec 07	123˚	–45˚	10˚	40	10
Monocerotids (Dec)	FM	Nov 27 – Dec 17	Dec 09	100˚	+08˚	5˚	42	3
sigma-Hydrids	LQ	Dec 03 – Dec 15	Dec 12	127˚	+02˚	5˚	58	2
Geminids	LQ	Dec 07 – Dec 17	Dec 14	112˚	+33˚	5˚	35	120
Coma Berenicids	NM	Dec 12 – Jan 23	Dec 20	175˚	+25˚	5˚	65	5
Ursids	NM	Dec 17 – Dec 26	Dec 22	217˚	+76˚	5˚	33	10

Notes On The Table Above

Shower Name The shower is named after the constellation that the radiant appears in or a bright star near that point. A shower marked with an asterisk (*) is only occasionally active.

Moon Phase The phase of the Moon nearest the date of maximum activity. If a Full Moon occurs near a shower's maximum period, only the very brightest of meteors will be seen.

Activity Duration The approximate dates when the shower is active.

Max Act The date when maximum activity can be expected.

Radiant: The position of the shower radiant in right ascension and declination (R.A. is expressed in degrees). These co-ordinates refer to the radiant position on the date of maximum activity.

Dia The radiant diameter. When two figures are given, the first is the spread in R.A. and the second the spread in Dec.

Vel The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11km/s (very slow) to 71km/s (very fast), medium speed is about 40km/s.

ZHR Zenith Hourly Rate. A theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

PART III – APPENDICES

CONSTELLATIONS – Abbreviations and Culmination at 9pm

Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.
Andromeda	Andromedae	And	Nov 23	Crux	Crucis	Cru	May 12	Orion	Orionis	Ori	Jan 27
Antlia	Antliae	Ant	Apr 10	Cygnus	Cygni	Cyg	Sep 13	Pavo	Pavonis	Pav	Aug 29
Apus	Apodis	Aps	Jul 5	Delphinus	Delphini	Del	Sep 14	Pegasus	Pegasi	Peg	Oct 16
Aquarius	Aquarii	Aqr	Oct 9	Dorado	Doradus	Dor	Jan 31	Perseus	Persei	Per	Dec 22
Aquila	Aquilae	Aql	Aug 30	Draco	Draconis	Dra	Jul 8	Phoenix	Phoenicis	Phe	Nov 18
Ara	Arae	Ara	Jul 25	Equuleus	Equulei	Equ	Sep 22	Pictor	Pictoris	Pic	Jan 30
Aries	Arietis	Ari	Dec 14	Eridanus	Eridani	Eri	Dec 25	Pisces	Piscium	Psc	Nov 11
Auriga	Aurigae	Aur	Feb 4	Fornax	Fornacis	For	Dec 17	Piscis Austrinus	Piscis Austrini	PsA	Oct 9
Bootes	Bootis	Boo	Jun 16	Gemini	Geminorum	Gem	Feb 19	Puppis	Puppis	Pup	Feb 22
Caelum	Caeli	Cae	Jan 15	Grus	Gruis	Gru	Oct 12	Pyxis	Pyxidis	Pyx	Mar 21
Camelopardus	Camelopardi	Cam	Feb 6	Hercules	Herculis	Her	Jul 28	Reticulum	Reticuli	Ret	Jan 3
Cancer	Cancri	Cnc	Mar 16	Horologium	Horologii	Hor	Dec 25	Sagitta	Sagittae	Sge	Aug 30
Canes Venatici	Canum Venaticorum	CVn	May 22	Hydra	Hydrae	Hya	Apr 29	Sagittarius	Sagittarii	Sgr	Aug 21
				Hydrus	Hydri	Hyi	Dec 10	Scorpius	Scorpii	Sco	Jul 18
Canis Major	Canis Majoris	CMa	Feb 16	Indus	Indi	Ind	Sep 26	Sculptor	Sculptoris	Scl	Nov 10
Canis Minor	Canis Minoris	CMi	Feb 28	Lacerta	Lacertae	Lac	Oct 12	Scutum	Scuti	Sct	Aug 15
Capricornus	Capricorni	Cap	Sep 22	Leo	Leonis	Leo	Apr 15	Serpens	Serpentis	Ser	Jul 21
Carina	Carinae	Car	Mar 17	Leo Minor	Leonis Minoris	LMi	Apr 9	Sextans	Sextantis	Sex	Apr 8
Cassiopeia	Cassiopeiae	Cas	Nov 23	Lepus	Leporis	Lep	Jan 28	Taurus	Tauri	Tau	Jan 14
Centaurus	Centauri	Cen	May 14	Libra	Librae	Lib	Jun 23	Telescopium	Telescopii	Tel	Aug 24
Cepheus	Cephei	Cep	Nov 13	Lupus	Lupi	Lup	Jun 23	Triangulum	Trianguli	Tri	Dec 7
Cetus	Ceti	Cet	Nov 29	Lynx	Lyncis	Lyn	Mar 5	Triangulum Australe	Trianguli Australis	TrA	Jul 7
Chamaeleon	Chamaeleontis	Cha	Apr 15	Lyra	Lyrae	Lyr	Aug 18				
Circinus	Circini	Cir	Jun 14	Mensa	Mensae	Men	Jan 28	Tucana	Tucanae	Tuc	Nov 1
Columba	Columbae	Col	Feb 1	Microscopium	Microscopii	Mic	Sep 18	Ursa Major	Ursae Majoris	UMa	Apr 25
Coma Berenices	Comae Berenices	Com	May 17	Monoceros	Monocerotis	Mon	Feb 19	Ursa Minor	Ursae Minoris	UMi	Jun 27
Corona Australis	Coronae Australis	CrA	Aug 14	Musca	Muscae	Mus	May 14	Vela	Velorum	Vel	Mar 30
Corona Borealis	Coronae Borealis	CrB	Jul 3	Norma	Normae	Nor	Jul 3	Virgo	Virginis	Vir	May 26
Corvus	Corvi	Crv	May 12	Octans	Octantis	Oct	Circum	Volans	Volantis	Vol	Mar 4
Crater	Crateris	Crt	Apr 26	Ophiuchus	Ophiuchi	Oph	Jul 26	Vulpecula	Vulpeculae	Vul	Sep 8

BRIGHTEST and NEAREST STARS (see tables on page 138)

The column descriptions are:

Designation The name of the star in the system created by Bayer, who numbered the stars in the constellations using Greek letters (p. 152). They were usually ordered by their brightness, Alpha being the brightest in most cases.

Name Common name for each star

Constellation The star's constellation.

RA and Dec. The position of the star, epoch 2000.0.

Magnitude App. The apparent magnitude as seen in the sky.

Magnitude Abs. The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light years) from Earth.

Spectral Type The spectral classification of the star (see below).

Parallax see glossary.

Proper Motion (see glossary)

Distance, ly is light year and **pc** is parsec (see glossary)

Note (d) is a visual double star
(sb) is a spectroscopic binary,
(eb) is an eclipsing binary and
(v) indicates the star is variable.

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O**, **B**, **A**, **F**, **G**, **K** and **M**, remembered by the mnemonic **O**h **B**e **A** **F**ine **G**irl(Guy) **K**iss **M**e.

There are also now the 'colder' star classes, **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and also given a luminosity class I, II, III, IV, etc. A discussion of this is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel)
- **F** and **G** are yellow (e.g., Capella, and the Sun)
- Late **K** (subclass > 5) and **M** stars are the cooler orange and red stars (e.g., Aldebaran, Betelgeuse).

It is an interesting exercise trying to see the colour of stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only in shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (i.e., no colour).

The colours of stars can be photographed simply. Mount your normal 35mm camera on a tripod and take a time exposure (some minutes) using a fast film. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., piggy-backed on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images burn out on the negative. All such photography should be conducted in country areas, away from city lights.

MESSIER OBJECTS (Epoch 2000.0)

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M1	NGC1952	05 34.5	+ 22° 01'	6	Tau	SNR	8.4	5,3	Crab Nebula, remnant from supernova of A.D. 1054
M2	NGC7089	21 33.5	- 00° 49'	12.9	Aqr	GC	6.5	8	
M3	NGC5272	13 42.2	+ 28° 23'	16.2	CVn	GC	6.4	7	Large bright globular, brightens suddenly towards the middle
M4	NGC6121	16 23.6	- 26° 32'	26.3	Sco	GC	5.9	6	Conspicuous globular near Antares
M5	NGC5904	15 18.6	+ 02° 05'	17.4	Ser	GC	5.8	6	Bright, large very compressed in middle, slightly oval in shape
M6	NGC6405	17 40.1	- 32° 13'	15	Sco	OC	4.2	6,8	Butterfly Cluster, 80 stars
M7	NGC6475	17 53.9	- 34° 49'	80	Sco	OC	3.3	6,8	Ptolemy's Cluster, 80 stars brighter than 10th magnitude
M8	NGC6523	18 03.8	- 24° 23'	90	Sgr	BN	3.5	6,8	Lagoon Nebula, densest section known as the Hourglass, dark lane
M9	NGC6333	17 19.2	- 18° 31'	9.3	Oph	GC	7.9	6	
M10	NGC6254	16 57.1	- 04° 06'	15.1	Oph	GC	6.6	6	
M11	NGC6705	18 51.1	- 06° 16'	14	Sct	OC	5.8	8	Wild Duck Cluster, rich and compact open cluster
M12	NGC6218	16 47.2	- 01° 57'	14.5	Oph	GC	6.6	6	
M13	NGC6205	16 41.7	+ 36° 28'	16.6	Her	GC	5.9	7,9	Great Hercules Cluster, showpiece of northern skies
M14	NGC6402	17 37.6	- 03° 15'	11.7	Oph	GC	7.6	6,7	
M15	NGC7078	21 30.0	+ 12° 10'	12.3	Peg	GC	6.4	9	Bright, irregularly round, well resolved into faint stars
M16	NGC6611	18 18.8	- 13° 47'	35	Ser	BN	6	6,8	Associated with Eagle Nebula
M17	NGC6618	18 20.8	- 16° 11'	46	Sgr	BN	6	6,8	Omega or Swan Nebula
M18	NGC6613	18 19.9	- 17° 08'	9	Sgr	OC	6.9	6,8	
M19	NGC6273	17 02.6	- 26° 16'	13.5	Oph	GC	7.2	6	
M20	NGC6514	18 02.3	- 23° 02'	29	Sgr	BN	6.3	6,8	Trifid Nebula, emission and reflection nebulosity cut by dark lanes
M21	NGC6531	18 04.6	- 22° 30'	13	Sgr	OC	5.9	6,8	
M22	NGC6656	18 36.4	- 23° 54'	24	Sgr	GC	5.1	1,6,8	Fine globular, only Omega Centauri and 47 Tucanae are brighter
M23	NGC6494	17 56.8	- 19° 01'	27	Sgr	OC	5.5	6,8	150 stars, moderate brightness range, lies in good star field
M24	NGC6603	18 18.4	- 18° 25'	5	Sgr	OC		6,8	Sagittarius Star Cloud, Delle Caustiche
M25	IC4725	18 31.6	- 19° 15'	32	Sgr	OC	4.6	6,8	30 stars loosely scattered
M26	NGC6694	18 45.2	- 09° 24'	15	Sct	OC	8	8	
M27	NGC6853	19 59.6	+ 22° 43'	15.2	Vul	PN	7.3	9	Dumbbell Nebula, bright dumbbell shaped, 14th mag. central star
M28	NGC6626	18 24.5	- 24° 52'	11.2	Sgr	GC	6.9	1,6,8	Large, round, increasingly compressed in the middle
M29	NGC6913	20 23.9	+ 38° 32'	7	Cyg	OC	6.6	9	
M30	NGC7099	21 40.4	- 23° 11'	11	Cap	GC	7.5	8	
M31	NGC224	00 42.7	+ 41° 16'	178	And	SG	3.5	3,9	Andromeda Galaxy
M32	NGC221	00 42.7	+ 40° 52'	7.6	And	EG	8.2	3,9	
M33	NGC598	01 33.9	+ 30° 39'	62	Tri	SG	5.7	3	Triangulum or Pinwheel Galaxy, member of Local Group
M34	NGC1039	02 42.0	+ 42° 47'	35	Per	OC	5.2	3	
M35	NGC2168	06 08.9	+ 24° 20'	28	Gem	OC	5.1	3,5	200 stars, magnitude 9 to 16
M36	NGC1960	05 36.1	+ 34° 08'	12	Aur	OC	6	3,5	60 stars, magnitude 9 to 14
M37	NGC2099	05 52.4	+ 32° 33'	24	Aur	OC	5.6	3,5	150 stars, magnitude range 9 to 12.5
M38	NGC1912	05 28.7	+ 35° 50'	21	Aur	OC	6.4	3,5	100 stars, mag 9.5 in splendid field
M39	NGC7092	21 32.2	+ 48° 26'	32	Cyg	OC	4.6	9	
M40	WNC 4	12 22.4	+ 58° 05'	0	UMa	DS	-	5,7	Double Star WNC4
M41	NGC2287	06 46.0	- 20° 44'	38	CMa	OC	4.5	4	80 stars, 7th magnitude and fainter, with 6.9 mag. red star near centre
M42	NGC1976	05 35.4	- 05° 27'	66	Ori	BN	3.7	2,3	Orion Nebula, emission and reflection nebula
M43	NGC1982	05 35.6	- 05° 16'	20	Ori	BN		1,3	de Mairan's nebula; part of Orion Nebula
M44	NGC2632	08 40.1	+ 19° 59'	95	Cnc	OC	3.1		Praesepe or Beehive Cluster, very large cluster, 50 stars
M45	Pleiades	03 47.0	+ 24° 07'	120	Tau	OC	1.2	3	Seven Sisters. naked-eye cluster
M46	NGC2437	07 41.8	- 14° 49'	27	Pup	OC	6.1	4	Rich open cluster, 100 stars, planetary nebula NGC2438 in same field
M47	NGC2422	07 36.6	- 14° 30'	30	Pup	OC	4.4	4	Large coarse cluster with 30 stars
M48	NGC2548	08 13.8	- 05° 48'	54	Hya	OC	5.8	4	Large cluster of 80 stars 8 to 13th mag.
M49	NGC4472	12 29.8	+ 08° 00'	8.9	Vir	EG	8.4	7	
M50	NGC2323	07 03.2	- 08° 20'	16	Mon	OC	5.9	4	Rich cluster, 80 stars mags 8 to 12
M51	NGC5194	13 29.9	+ 47° 12'	11	CVn	SG	8.4	5	Whirlpool Galaxy
M52	NGC7654	23 24.2	+ 61° 35'	13	Cas	OC	6.9	3,9	
M53	NGC5024	13 12.9	+ 18° 10'	12.6	Com	GC	7.7	7	Bright centre region, very compressed
M54	NGC6715	18 55.1	- 30° 29'	9.1	Sgr	GC	7.7	1,6,8	
M55	NGC6809	19 40.0	- 30° 58'	19	Sgr	GC	6.3	8	
M56	NGC6779	19 16.6	+ 30° 11'	7.1	Lyr	GC	8.3	9	Irregularly round, compressed in the middle
M57	NGC6720	18 53.6	+ 33° 02'	2.5	Lyr	PN	8.6	7,9	Ring Nebula, ring structure
M58	NGC4579	12 37.7	+ 11° 49'	5.4	Vir	SG	9.8	7	Bright diffuse nucleus, dark lanes
M59	NGC4621	12 42.0	+ 11° 39'	5.1	Vir	EG	9.8	7	
M60	NGC4649	12 43.7	+ 11° 33'	7.2	Vir	EG	8.8	7	
M61	NGC4303	12 21.9	+ 04° 28'	6	Vir	SG	9.7	7	
M62	NGC6266	17 01.2	- 30° 07'	14.1	Oph	GC	6.6	6,8	
M63	NGC5055	13 15.8	+ 42° 02'	12.3	CVn	SG	8.6	5,7	Sunflower Galaxy
M64	NGC4826	12 56.7	+ 21° 41'	9.3	Com	SG	8.5	7	Blackeye Galaxy
M65	NGC3623	11 18.9	+ 13° 05'	10	Leo	SG	9.3	5	
M66	NGC3627	11 20.2	+ 12° 59'	8.7	Leo	SG	9	5	
M67	NGC2682	08 50.4	+ 11° 49'	30	Cnc	OC	6.9	5	200 stars mag. 10-15, large and rich
M68	NGC4590	12 39.5	- 26° 45'	12	Hya	GC	8.2	4,6	Rich and compressed
M69	NGC6637	18 31.4	- 32° 21'	7.1	Sgr	GC	7.7	1,6,8	
M70	NGC6681	18 43.2	- 32° 18'	7.8	Sgr	GC	8.1	1,6,8	
M71	NGC6838	19 53.8	+ 18° 47'	7.2	Sge	GC	8.3	9	
M72	NGC6981	20 53.5	- 12° 32'	5.9	Aqr	GC	9.4	8	
M73	NGC6994	20 59.0	- 12° 38'	3	Aqr	OC	9	8	
M74	NGC628	01 36.7	+ 15° 47'	10.2	Psc	SG	9.2	3	

	Other Ref	R.A.	Dec	Size	Con.	Type	Mag	Map	Notes
M75	NGC6864	20 06.1	- 21° 55'	6	Sgr	GC	8.6	8	
M76	NGC650	01 42.3	+ 51° 34'	4.8	Per	PN	10.2	3,9	Little Dumbbell Nebula, Cork Nebula
M77	NGC1068	02 42.7	- 00° 01'	6.9	Cet	SG	8.8	2	Seyfert type with very bright nucleus
M78	NGC2068	05 46.7	+ 00° 03'	8	Ori	BN	8.0	2,3	Brightest & largest in group of 4 nebulae
M79	NGC1904	05 24.5	- 24° 33'	8.7	Lep	GC	7.8	2,4	Rich and compressed, well resolved
M80	NGC6093	16 17.0	- 22° 59'	8.9	Sco	GC	7.2	6	Strong central concentration, bright & large
M81	NGC3031	09 55.6	+ 69° 04'	25.7	UMa	SG	6.9	5	Bode's Galaxy
M82	NGC3034	09 55.8	+ 69° 41'	11.2	UMa	IG	8.4	5	Cigar Galaxy
M83	NGC5236	13 37.0	- 29° 52'	11.2	Hya	SG	7.6	6	Southern Pinwheel Galaxy
M84	NGC4374	12 25.1	+ 12° 53'	5	Vir	EG	9.3	7	Bright centre, in same field as M86
M85	NGC4382	12 25.4	+ 18° 11'	7.1	Com	EG	9.2	5,7	
M86	NGC4406	12 26.2	+ 12° 57'	7.4	Vir	EG	9.2	7	
M87	NGC4486	12 30.8	+ 12° 24'	7.2	Vir	EG	8.6	7	Virgo A, bright, smooth & featureless
M88	NGC4501	12 32.0	+ 14° 25'	6.9	Com	SG	9.5	7	
M89	NGC4552	12 35.7	+ 12° 33'	4.2	Vir	EG	9.8	7	
M90	NGC4569	12 36.8	+ 13° 10'	9.5	Vir	SG	9.5	7	
M91	NGC4548	12 35.4	+ 14° 30'	5.4	Com	SG	10.2	7	
M92	NGC6341	17 17.1	+ 43° 08'	11.2	Her	GC	6.5	7,9	
M93	NGC2447	07 44.6	- 23° 52'	22	Pup	OC	6.2	4	80 stars magnitude 8 to 13
M94	NGC4736	12 50.9	+ 41° 07'	11	CVn	SG	8.2	5,7	
M95	NGC3351	10 44.0	+ 11° 42'	7.4	Leo	SG	9.7	4,5	
M96	NGC3368	10 46.8	+ 11° 49'	7.1	Leo	SG	9.2	4,5	
M97	NGC3587	11 14.8	+ 55° 01'	3.2	UMa	PN	9.7	5,7	Owl Nebula
M98	NGC4192	12 13.8	+ 14° 54'	9.5	Com	SG	10.1	5,7	
M99	NGC4254	12 18.8	+ 14° 25'	5.4	Com	SG	9.8	5,7	
M100	NGC4321	12 22.9	+ 15° 49'	6.9	Com	SG	9.4	5,7	
M101	NGC5457	14 03.2	+ 54° 21'	26.9	UMa	SG	7.7	7	Pinwheel Galaxy
M102									Same as M101
M103	NGC581	01 33.2	+ 60° 42'	6	Cas	OC	7.4	3,9	
M104	NGC4594	12 40.0	- 11° 37'	8.9	Vir	SG	8.3	6	Sombrero Galaxy
M105	NGC3379	10 47.8	+ 12° 35'	4.5	Leo	EG	9.3	4,5	
M106	NGC4258	12 19.0	+ 47° 18'	18.2	CVn	SG	8.3	5,7	
M107	NGC6171	16 32.5	- 13° 03'	10	Oph	GC	8.1	6	
M108	NGC3556	11 11.5	+ 55° 40'	8.3	UMa	SG	10.1	5,7	
M109	NGC3992	11 57.6	+ 53° 23'	7.6	UMa	SG	9.8	5,7	
M110	NGC205	00 40.4	+ 41° 41'	17.4	And	EG	8.1	3,9	

LEGEND

Other Ref/ Cat Catalogue number (NGC New General Catalogue, IC Index Catalog, 'M' Messier number)

R.A. Right Ascension (hh mm.m, Epoch 2000.0)

Dec Declination (° ', Epoch 2000.0)

Size In arc minutes

Con. Constellation

Type Object type (see intro Part I p. 18)

Mag Magnitude of object

Map All Sky Map number (pp. 70-79)

Notes Common name and/or description

OTHER NON-STELLAR OBJECTS (Epoch 2000.0)

Cat	R.A.	Dec	Size	Con.	Type	Mag	Notes
SMC	00 52.7	-72° 30'	5°x4°	Tuc	IG	2.3	Small Magellanic Cloud. Visible to unaided eye from dark sky
NGC55	00 14.9	-39° 11'	30'x6.3'	Scl	SG	8.1	A bright galaxy in the Sculptor Group
NGC104	00 24.1	-72° 05'	30.9'	Tuc	GC	3.8	47 Tucanae, one of the finest globulars
NGC253	00 47.6	-25° 17'	30'x6.9'	Scl	SG	7.6	Silver Coin galaxy. Large, bright edge-on spiral
Hyades	04 27.0	+16° 00'	6°	Tau	OC	0.5	Naked-eye, V-shaped cluster. 28 stars, the brightest mag. 3 and 4
LMC	05 23.6	-69° 45'	9°x10°	Dor	IG	0.1	Large Magellanic Cloud. Visible to unaided eye from dark sky
NGC2070	05 38.6	-69° 05'	30'x20'	Dor	BN	5.4	30 Doradus, Tarantula Nebula, complex structure
NGC2169	06 08.4	+13° 57'	6'	Ori	OC	5.9	Rich loose cluster, 30 stars magnitude 7 and fainter
NGC2244	06 32.4	-04° 52'	23'	Mon	OC	4.8	100 stars, with nebulosity (Rosette Nebula)
NGC2264	06 41.1	+09° 53'	20'	Mon	OC	3.9	Christmas Tree cluster
NGC2301	06 51.8	+00° 28'	12'	Mon	OC	6.0	Rich cluster, 80 stars, large magnitude range
NGC2362	07 18.8	-24° 57'	8'	CMa	OC	4.1	60 stars, large brightness range (4th mag. down)
NGC2451	07 45.4	-37° 58'	45'	Pup	OC	2.8	Rich in stars with slight central concentration
NGC2477	07 52.3	-38° 33'	27'	Pup	OC	5.8	160 stars, mag. 10 to 12, central concentration
NGC2516	07 58.3	-60° 52'	29'	Car	OC	3.8	80 stars 6th mag. and fainter, central concentration
NGC2547	08 10.7	-49° 16'	74'	Vel	OC	4.7	Rich in stars with strong central concentration
IC2391	08 40.2	-53° 04'	50'	Vel	OC	2.5	Moderately rich in bright and faint stars
IC2395	08 41.1	-48° 12'	7'	Vel	OC	4.6	40 stars 6th magnitude and fainter
NGC2808	09 12.0	-64° 52'	13.8'	Car	GC	6.1	Large and rich, compressed centre, mag 13 – 15
NGC3114	10 02.7	-60° 07'	35'	Car	OC	4.2	Rich cluster, stars 9 to 14th magnitude
NGC3132	10 07.1	-40° 26'	30"	Vel	PN	8.2	The Eight Burst Nebula, ring and disk
IC2602	10 43.2	-64° 24'	50'	Car	OC	1.9	Central concentration, brightest mag. 3
NGC3372	10 43.8	-59° 52'		Car	BN	2.5	Eta Carinae Nebula, bright, prominent dark lanes
NGC3532	11 06.4	-58° 40'	55'	Car	OC	3.0	Rich and large, 150 stars 7 to 12th magnitude
NGC3766	11 36.1	-61° 37'	12'	Cen	OC	5.3	Rich cluster, 100 stars magnitude range 7 to 12th
NGC4755	12 53.6	-60° 20'	10'	Cru	OC	4.2	Jewel Box, rich in stars, large brightness range
NGC4945	13 05.4	-49° 28'	23'x5.9'	Cen	SG	9.0	Big edge on spiral, small galaxy in same field
NGC5128	13 25.5	-43° 01'	31'x23'	Cen	G	6.7	Centaurus A, bright sphere crossed by dark lane
NGC5139	13 26.8	-47° 29'	36'	Cen	GC	3.5	Omega Centauri, perhaps the finest globular cluster
NGC5281	13 46.6	-62° 54'	5'	Cen	OC	5.9	40 stars, moderately rich in bright and faint stars
NGC5617	14 29.8	-60° 43'	10'	Cen	OC	6.3	80 stars, large brightness range, central conc.
NGC6025	16 03.7	-60° 30'	12'	TrA	OC	5.1	60 stars, large brightness range
NGC6067	16 13.2	-54° 13'	12'	Nor	OC	5.6	100 stars, large brightness range, central conc.
NGC6087	16 18.9	-57° 54'	12.5'	Nor	OC	5.4	40 stars, moderate brightness range
NGC6124	16 25.6	-40° 40'	29'	Sco	OC	5.8	100 stars, large brightness range
NGC6193	16 41.3	-48° 46'	14'	Ara	OC	5.2	Few stars, large brightness range
NGC6231	16 54.0	-41° 48'	14'	Sco	OC	2.6	A few stars with strong central concentration
NGC6397	17 40.7	-53° 40'	25.7'	Ara	GC	5.8	Loose structure, possibly the nearest globular
NGC7009	21 04.2	-11° 22'	25"	Aqr	PN	7.9	Saturn Nebula, ring structure in a larger faint halo
NGC7293	22 29.6	-20° 48'	12'	Aqr	PN	7.3	Helix Nebula, ring structure in large, fainter disk

THE BRIGHTEST STARS (see explanation p. 135)

Designation		Name	Constellation	R.A. (2000.0)	Dec (2000.0)	Magnitude App	Magnitude Abs	Spectral Type	Parallax	Distance pc	Distance ly	Note
1	α CMa	Sirius	Canis Major	06 45.1	–16 43	–1.44	1.5	A1 V	0.3800	2.63	8.58	d
2	α Car	Canopus	Carina	06 23.9	–52 42	–0.74	–5.6	F0 Ib	0.0104	96	310	
3	α Cen	Rigil Kent	Centaurus	14 39.6	–60 50	–0.28	4.1	G2V + K0V	0.7472	1.34	4.37	d
4	α Boo	Arcturus	Bootes	14 15.7	+19 11	–0.05	–0.3	K2 III	0.0889	11.3	36.7	
5	α Lyr	Vega	Lyra	18 36.9	+38 47	0.03	0.6	A0 V	0.1289	7.76	25.3	v
6	α Aur	Capella	Auriga	05 16.7	+46 00	0.08	–0.5	G8III + G0III	0.0773	12.9	42.2	sb, v
7	β Ori	Rigel	Orion	05 14.5	–08 12	0.15	–6.8	B8 Ia	0.0042	240	780	d, v
8	α CMi	Procyon	Canis Minor	07 39.3	+05 14	0.38	2.7	F5 IV–V	0.2861	3.50	11.4	d
9	α Eri	Achernar	Eridanus	01 37.7	–57 14	0.45	–2.8	B5 IV	0.0227	44.1	144	v
10	α Ori	Betelgeuse	Orion	05 55.2	+07 24	0.50	–5.2	M2 Iab	0.0076	131	430	v
11	β Cen	Hadar	Centaurus	14 03.8	–60 22	0.61	–5.4	B1 II + B	0.0062	161	525	d, v
12	α Cru	Acrux	Crux	12 26.6	–63 06	0.74	–4.2	B0.5IV + B0.5V	0.0102	98	320	d
13	α Aql	Altair	Aquila	19 50.8	+08 52	0.76	2.2	A7 IV–V	0.1950	5.13	16.7	
14	α Tau	Aldebaran	Taurus	04 35.9	+16 31	0.87	–0.6	K5 III	0.0501	20.0	65	v
15	α Sco	Antares	Scorpius	16 29.4	–26 26	0.96	–5.1	M1.5Iab + B4V	0.0067	150	490	d, v
16	α Vir	Spica	Virgo	13 25.2	–11 10	0.98	–3.5	B1III–IV + B2V	0.0124	80	262	sb, v
17	β Gem	Pollux	Gemini	07 45.3	+28 02	1.15	1.1	K0 III	0.0967	10.3	33.7	
18	α PsA	Fomalhaut	Piscis Austrinus	22 57.7	–29 37	1.16	1.7	A3 V	0.1301	7.69	25.1	
19	α Cyg	Deneb	Cygnus	20 41.4	+45 17	1.25	–7.2	A2 Ia	0.0020	500	1600	v
20	β Cru	Mimosa	Crux	12 47.7	–59 41	1.26	–3.9	B0.5 III	0.0093	108	353	v
21	α Leo	Regulus	Leo	10 08.4	+11 58	1.36	–0.5	B7 V	0.0421	23.8	78	d
22	ε CMa	Adhara	Canis Major	06 58.6	–28 58	1.50	–4.1	B2 II	0.0076	132	430	d
23	α Gem	Castor	Gemini	07 34.6	+31 53	1.58	0.6	A1V + Am	0.0633	15.8	52	d,sb
24	λ Sco	Shaula	Scorpius	17 33.6	–37 06	1.62	–5.0	B1.5 III	0.0046	215	700	sb, v
25	γ Cru	Gacrux	Crux	12 31.2	–57 07	1.63	–0.5	M3 III	0.0371	27.0	88	v
26	γ Ori	Bellatrix	Orion	05 25.1	+06 21	1.64	–2.7	B2 III	0.0134	75	243	
27	β Tau	El Nath	Taurus	05 26.3	+28 36	1.65	–1.4	B7 III	0.0249	40.2	131	
28	β Car	Miaplacidus	Carina	09 13.2	–69 43	1.67	–1.0	A0 III	0.0293	34.1	111	
29	ε Ori	Alnilam	Orion	05 36.2	–01 12	1.69	–6.4	B0 Ia	0.0024	410	1340	
30	γ Vel	Regor	Vela	08 09.5	–47 20	1.70	–5.4	O9Ib + WC8	0.0039	258	840	sb, v

THE NEAREST STARS (see explanation p. 135)

No	Star Name		Constellation	R.A. 2000.0 hh mm.m	Dec ° ‘	Magnitude Apparent	Magnitude Absolute	Spect Type	Parallax "	Proper Motion "/yr	Distance pc	Distance ly
--	Sun					–26.72	4.85	G2 V				
1	Proxima Centauri		Centaurus	14 29.7	–62 40	11.09	15.53	M5.5 V	0.7720	3.85	1.30	4.23
	Alpha Centauri	A	Centaurus	14 39.6	–60 50	0.01	4.38	G2 V	0.7472	3.71	1.34	4.37
		B				1.34	5.71	K0 V				
2	Barnard’s Star		Ophiuchus	17 57.8	+04 41	9.53	13.22	M4.0 V	0.5470	10.36	1.83	5.96
3	Wolf 359		Leo	10 56.5	+07 00	13.44	16.55	M6.0 V	0.4191	4.70	2.39	7.78
4	Lalande 21185		Ursa Major	11 03.3	+35 58	7.47	10.44	M2.0 V	0.3934	4.80	2.54	8.29
5	Sirius	A	Canis Major	06 45.1	–16 43	–1.44	1.46	A1 V	0.3800	1.34	2.63	8.58
		B				8.44	11.34	DA2				
6	L 726-8 (UV Ceti)	A	Cetus	01 39.0	–17 57	12.54	15.40	M5.5 V	0.3737	3.37	2.68	8.73
		B				12.99	15.85	M6.0 V				
7	Ross 154		Sagittarius	18 49.8	–23 50	10.43	13.07	M3.5 V	0.3369	0.67	2.97	9.68
8	Ross 248		Andromeda	23 41.9	+44 10	12.29	14.79	M5.5 V	0.3160	1.62	3.16	10.32
9	Epsilon Eridani		Eridanus	03 32.9	–09 27	3.73	6.19	K2 V	0.3100	0.98	3.23	10.52
10	Lacaille 9352		Piscis Austrinus	23 05.9	–35 51	7.34	9.75	M1.5 V	0.3036	6.90	3.29	10.74
11	Ross 128		Virgo	11 47.7	+00 48	11.13	13.51	M4.0 V	0.2987	1.36	3.35	10.92
12	L 789-6 (EZ Aquarii)	A	Aquarius	22 38.6	–15 18	13.33	15.64	M5.0 V	0.2895	3.25	3.45	11.27
		B				13.27	15.58	M				
		C				14.03	16.34	M				
13	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.66	F5 IV–V	0.2861	1.26	3.50	11.40
		B				10.70	12.98	DA				
14	61 Cygni	A	Cygnus	21 06.9	+38 45	5.21	7.49	K5.0 V	0.2860	5.28	3.50	11.40
		B				6.03	8.31	K7.0 V				
15	Σ 2398	A	Draco	18 42.8	+59 38	8.90	11.16	M3.0 V	0.2830	2.24	3.53	11.53
		B				9.69	11.95	M3.5 V				
16	Groombridge 34	A	Andromeda	00 18.4	+44 01	8.08	10.32	M1.5 V	0.2806	2.92	3.56	11.63
		B				11.06	13.30	M3.5 V				
17	Epsilon Indi		Indus	22 03.4	–56 47	4.69	6.89	K5 Ve	0.2758	4.70	3.63	11.83
18	DX Cancri		Cancer	08 29.8	+26 47	14.78	16.98	M6.5 V	0.2758	1.29	3.63	11.83
19	Tau Ceti		Cetus	01 44.1	–15 56	3.49	5.68	G8 Vp	0.2744	1.92	3.64	11.89
20	GJ 1061		Horologium	03 36.0	–44 31	13.03	15.21	M5.5 V	0.2720	0.81	3.68	11.99
21	YZ Ceti		Cetus	01 12.5	–17 00	12.02	14.17	M4.5 V	0.2688	1.37	3.72	12.13
22	Luyten’s Star		Canis Minor	07 27.4	+05 14	9.86	11.97	M3.5 V	0.2638	3.74	3.79	12.37

RISE AND SET TIME CORRECTIONS FOR OTHER LOCATIONS

As mentioned previously in this book, the rise/set tables for the Sun, Moon and planets in Part II are calculated for Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney.

This page is designed to help people who live outside these cities make corrections to determine the rise/set times for their specific location. There are two corrections needed, they are:

1. An adjustment for the difference in longitude. **For every degree of longitude east or west of Sydney, subtract or add respectively 4 minutes to both the rise and set times**. Examples of corrections for various towns and cities are given in table 1.
2. An adjustment for the difference in latitude also requires the declination for the object of interest. Table 2 presents these corrections (southern latitudes are negative). NB. **for rise times you add these values, for set you subtract**. For your specific latitude it is normally sufficient to interpolate these figures.

It is important that rise and set times for Sydney are used, irrespective of which town in Australia the calculations are for, when using these tables.

In all these calculations, it is easier to first convert all latitudes and longitudes to decimal degrees.

Example of rise/set time corrections:

Calculate the rise/set times for the Sun on January 14 for Albury (36° 05'S, 146° 55'E)

	Rise	Set
From page 87 the rise/set values for Sydney are:	4:58	19:09
Adjust for longitude (151.25–146.92) x 4 (table 1)	+ :17	+ :17
(value is positive due to Albury being west of Sydney)		
Adjust for latitude and declination of the Sun from table 2. Sun's declination is –21° 22' (p. 85)	– :05	+ :05
Rise/Set times for Albury are:	5:10	19:31

If your local time is Central Standard Time, **subtract** 30 minutes, if your local time is Western Standard Time, **subtract** 2 hours

If daylight saving is in force, **add** 60 minutes.

TABLE 2 – RISE/SET CORRECTIONS FOR LATITUDE/ DECLINATION (from Sydney)

South Latitude (negative)	Declination 30°	25°	20°	15°	10°	5°	0°	-5°	-10°	-15°	-20°	-25°	-30°
-12°	-63	-50	-39	-28	-19	-9	0	9	19	28	39	50	63
-14°	-58	-46	-36	-26	-17	-8	0	8	17	26	36	46	58
-16°	-53	-42	-33	-24	-16	-8	0	8	16	24	33	42	53
-18°	-48	-38	-29	-22	-14	-7	0	7	14	22	29	38	48
-20°	-43	-34	-26	-19	-13	-6	0	6	13	19	26	34	43
-22°	-37	-30	-23	-17	-11	-5	0	5	11	17	23	30	37
-24°	-32	-25	-19	-14	-9	-5	0	5	9	14	19	25	32
-26°	-26	-20	-16	-11	-7	-4	0	4	7	11	16	20	26
-28°	-20	-16	-12	-9	-6	-3	0	3	6	9	12	16	20
-30°	-13	-11	-8	-6	-4	-2	0	2	4	6	8	11	13
-32°	-7	-5	-4	-3	-2	-1	0	1	2	3	4	5	7
-34°	0	0	0	0	0	0	0	0	0	0	0	0	0
-36°	8	6	5	3	2	1	0	-1	-2	-3	-5	-6	-8
-38°	16	12	9	7	4	2	0	-2	-4	-7	-9	-12	-16
-40°	25	19	15	10	7	3	0	-3	-7	-10	-15	-19	-25
-42°	34	26	20	14	9	5	0	-5	-9	-14	-20	-26	-34
-44°	44	34	26	18	12	6	0	-6	-12	-18	-26	-34	-44

Table 1 **LONGITUDE ADJUSTMENTS FOR SOME TOWNS AND CITIES RELATIVE TO SYDNEY**

Location	Latitude (° ' S)	Longitude ° ' E)	Change in Longitude (decimal °)	correction (mins.)
NEW SOUTH WALES				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	32 0	141 27	9.8	39
Coffs Harbour	30 13	153 08	-1.9	-8
Dubbo	32 15	148 37	2.6	11
Goulburn	34 45	149 43	1.5	6
Katoomba	33 42	150 18	0.9	4
Newcastle	32 55	151 45	-0.5	-2
Parkes	33 05	148 10	3.1	12
Tamworth	31 03	151 02	0.2	1
Wagga Wagga	35 05	147 20	3.9	16
Wollongong	34 25	150 52	0.4	2
NORTHERN TERRITORY				
Alice Springs	23 42	133 56	17.3	69
Ayers Rock	25 11	130 58	20.3	8
QUEENSLAND				
Bundaberg	24 52	152 21	-1.1	-4
Cairns	16 55	145 49	5.4	22
Longreach	23 22	144 09	7.1	28
Mackay	21 08	149 10	2.1	8
Mount Isa	20 38	139 28	11.8	47
Rockhampton	23 21	150 28	0.8	3
Surfers Paradise	28 00	153 26	-2.2	-9
Toowoomba	27 33	151 58	-0.7	-3
Townsville	19 10	146 49	4.4	18
TASMANIA				
Launceston	41 20	147 08	4.1	16
Stanley	40 40	145 08	6.1	24
VICTORIA				
Ballarat	37 25	143 55	7.3	29
Benalla	36 30	146 01	5.2	21
Bendigo	36 46	144 17	7.1	28
Geelong	38 09	144 10	7.1	28
Morwell	38 12	146 21	4.9	20
Shepparton	36 13	145 25	5.8	23
Swan Hill	35 13	143 30	7.8	31
Wangaratta	36 17	146 13	5.0	20
Warnambool	38 27	142 30	8.8	35
SOUTH AUSTRALIA				
Port Augusta	32 30	137 52	13.4	54
Port Lincoln	34 42	135 59	15.3	61
Mount Gambier	37 41	140 49	10.4	42
Whyalla	33 02	137 34	13.7	55
WESTERN AUSTRALIA				
Albany	35 01	117 53	33.37	133
Broome	17 58	122 14	29.02	116
Bunbury	33 20	115 38	35.62	142
Carnarvon	24 53	113 40	37.58	150
Denmark	34 58	117 21	33.90	136
Derby	17 19	123 38	27.62	110
Esperance	33 52	121 54	29.35	117
Eucla	31 41	128 53	22.37	89
Fitzroy Crossing	18 11	125 36	25.65	103
Geraldton	28 46	114 37	36.63	147
Kalgoorlie	30 45	121 28	29.78	119
Kellerberrin	31 38	117 43	33.53	134
Lake Grace	33 06	118 28	32.78	131
Marble Bar	21 10	119 45	31.50	126
Meekatharra	26 36	118 28	32.78	131
Mount Barker	34 38	117 40	33.58	134
Mount Magnet	28 04	117 51	33.40	134
Mount Newman	23 19	119 45	31.50	126
Mount Tom Price	22 41	117 47	33.47	134
Norseman	32 12	121 47	29.47	118
Northam	31 39	116 40	34.58	138
Onslow	21 38	115 07	36.13	145
Port Hedland	20 18	118 35	32.67	131
Rawlinna	31 01	125 20	25.92	104
Southern Cross	31 14	119 19	31.93	128
Wagin	33 19	117 20	33.92	136
Wiluna	26 35	120 14	31.02	124
Wyndham	15 28	128 06	23.15	93
Yampi Sound	16 08	123 36	27.65	111

JULIAN DATE – 2006

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 10 hrs from EST, 9.5 hrs from CST or 8 hrs from WST, correcting the date if necessary. Next find the Julian date given in the table (below left) for the month you are interested in. Now add the day of the month. This will give you JD for 0hr UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you wish to know the Julian date at 23:00 EST on July 17th 2006. Subtract 10 hours to get UT.

23 – 10 = 13:00 hrs UT

From the table the JD for July is 2453916.5
Add the day of month, 17 gives us 2453933.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 23:00hr 17 July 2006 EST is 2453934.042

JULIAN DATE at 0hr UT	
Month	Julian Date
Jan 0	2453735.5
Feb 0	2453766.5
Mar 0	2453794.5
Apr 0	2453825.5
May 0	2453855.5
Jun 0	2453886.5
Jul 0	2453916.5
Aug 0	2453947.5
Sep 0	2453978.5
Oct 0	2454008.5
Nov 0	2454039.5
Dec 0	2454069.5

Hours as decimal of a day.			
01	0.042	13	0.542
02	0.083	14	0.583
03	0.125	15	0.625
04	0.167	16	0.667
05	0.208	17	0.708
06	0.250	18	0.750
07	0.292	19	0.792
08	0.333	20	0.833
09	0.375	21	0.875
10	0.417	22	0.917
11	0.458	23	0.958
12	0.500	24	1.000

SIDEREAL TIME – 2006

Jan 0	6.6347	May 0	14.5199	Sep 0	22.6022
Feb 0	8.6717	Jun 0	16.5569	Oct 0	0.5735
Mar 0	10.5116	Jul 0	18.5282	Nov 0	2.6105
Apr 0	12.5486	Aug 0	20.5652	Dec 0	4.5818

Greenwich mean sidereal time (GMST) at 0hr UT

You can use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to UT. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day d of month at hour t UT

= GMST at 0hr UT (from table above) + 0.06571 d + 1.00274 t

To convert this to local mean sidereal time (LMST) we use

LMST = GMST + east longitude (or – west longitude)

where longitude is expressed in HOURS (not degrees!)

To convert longitude from degrees to hours, just divide by 15.

Example:

Find LMST at 23 hours Sydney time (EST) on 17th July 2006.

23:00 EST = 13:00 UT

GMST for July 0 is 18.5282 hours.

GMST = 18.5282 + (0.06571 x 17) + (1.00274 x 13) = 32.6809

Sydney's longitude is 151.25°, which is 10.0833 hrs so

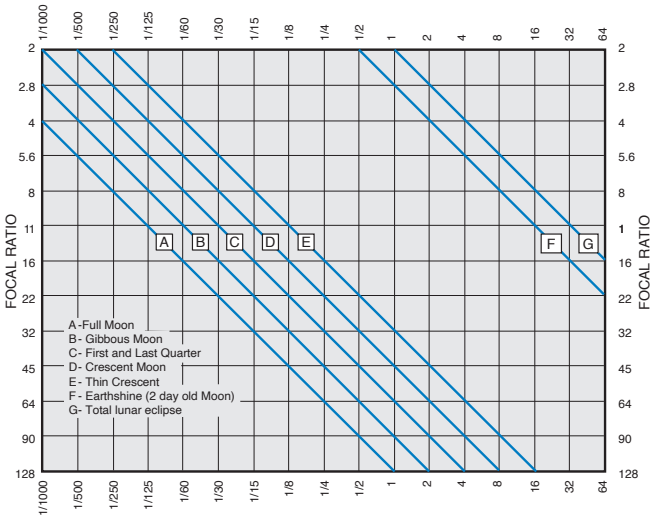
LMST = 32.6809 + 10.0833 = 42.7642

Subtract from this multiples of 24 until it is in the range of 0 to 24

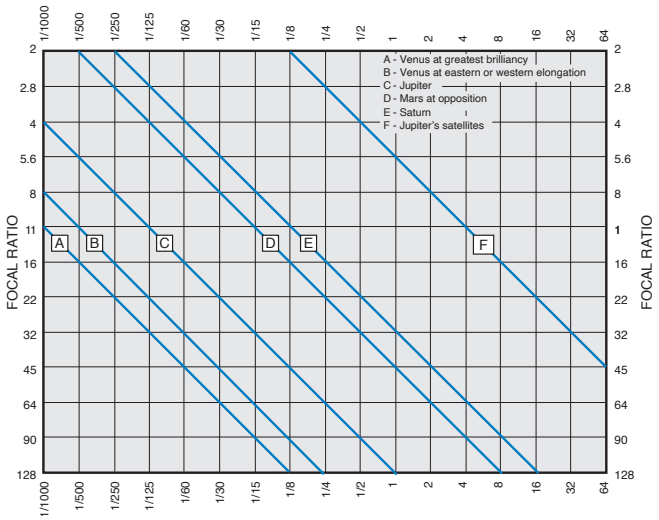
42.7642 – 24 = 18.7642 hrs or 18h 45m 51s

PHOTOGRAPHIC EXPOSURE GUIDES

MOON



PLANETS



These charts provide recommended photographic exposures for the Moon (left) and selected planets (right) using 100 ISO film. The charts should only be treated as a guide, as many factors will influence the exposure time.

Follow a horizontal line nearest to your systems focal ratio to the oblique line that represents the Moon aspect or planet required, then follow the intersecting vertical line down to find the correct exposure.

For the best result, always take one photo at the recommended speed and follow up with one at half and one at twice the exposure (bracketing). This will help smooth out variables and should provide at least one image at the required density.

Film Speed	Multiply By	Film Speed	Divide By	*For ISO values other than 100, apply these factors to the exposure time.*
32 ISO	4	200 ISO	2	
64 ISO	2	400 ISO	4	

Places of Astronomical Interest

Following is a list of places of astronomical interest. These facilities cater to the public in regards to tours and or displays. Information is subject to change. Links to all of the web sites listed here can be found on the Quasar Publishing site: www.quasarastronomy.com.au

NEW SOUTH WALES & ACT

BATHURST OBSERVATORY

This observatory is located 10km from Bathurst. Their dome houses a 14 inch telescope to view the dark rural skies. They also have a radio telescope for listening to signals from the Milky Way. Accommodation for individuals or groups is available at the adjacent Rossmore Park. The local Centaurus Astronomical Society has regular meetings there as well.

Address	Rossmore Park, 624 Limekilns Road, Bathurst NSW 2795
Times	The observatory is open every clear night of the year except on Sundays (also closed on Christmas Eve, Christmas Day and Boxing Day) with tour times varying depending on the season.
Contact	Ray and Cindy Pickard on (02) 6337 3988
Email	info@bathurstobservatory.com.au
Web	bathurstobservatory.com.au/

LINDEN OBSERVATORY

WSAAG (Western Sydney Amateur Astronomy Group) holds two observing nights a month, where anyone can drop in and look through their telescopes. Observing nights are usually held on Saturdays closest to the New Moon. Dates can be obtained by visiting the WSAAG website.

Address	105 Glossop Road, Linden NSW 2778
Cost	Donation to Linden Trust @ $5 per person.
Contact	Western Sydney Amateur Astronomy Group for more info.
Email	wsaag@tpg.com.au
Web	www4.tpgi.com.au/users/wsaag/

PORT MACQUARIE OBSERVATORY

This facility, operated by the Port Macquarie Astronomical Association, is situated in Rotary Park (opposite Town Beach) Port Macquarie. It is open to the public on Sunday and Wednesday evenings (also Friday during NSW school holidays). A multimedia presentation is given and celestial objects can be viewed through the 14 inch telescope. Special nights can be arranged for groups.

Address	PO Box 1453, Port Macquarie NSW 2444
Times	Sunday & Wednesday evenings (no bookings required) at 7:30 pm (8:15 pm during daylight savings). Doors open 15 minutes before session times.
Cost	$5 adults, $4 children, $15 family (2+2)
Contact	Matthew Wallace (02) 6584 9164 or Jim Daniel (02) 6583 1933
Email	info@pmobs.org.au
Web	www.pmobs.org.au

THE CANBERRA SPACE DOME AND OBSERVATORY

The Canberra Space Dome (Planetarium) is a virtual reality star theatre. Experience night sky simulations, interplanetary space flight, and explore the night sky. The observatory features research-grade telescopes under domes.

Address	Hawdon Place, Dickson (off Antil Street)
Email	planetarium@ctuc.asn.au
Web	www.ctuc.asn.au/planetarium/

GROVE CREEK OBSERVATORY

This observatory is located 60km south of Bathurst and is run as a non-profit organisation. The facility caters for amateur astronomers who are looking to use large aperture telescopes under very dark skies. The facility boasts a C14, a 12.5 inch Newtonian, Meade LX-200s with astrophotography and CCD cameras. The observatory has on-site accommodation, sleeping up to 8 people.

Cost	$240 per night, up to 3 people, $60 per extra person; sleeps up to 8 people.
Contact	(02) 6368 8611 or 0418 866 179, 2pm – 9pm
Email	bookings@gco.org.au
Web	www.gco.org.au/

RYDER HOMESTEAD OBSERVATORY

As well as providing accommodation in self contained log cabins, Ryder Homestead offers guests guided star gazing tours. Located 30 minutes north of Bathurst the Homestead enjoys very dark country skies.

Address	130 Thompson Street, Wattle Flat NSW 2795
Cost	Homestead guests free, otherwise adults $8, children $5, family $25
Contact	Rodney Watters on (02) 6337 7171
Email	rwryder@ryderhome.com.au
Web	www.ryderhome.com.au

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two buildings house 41cm and 35cm telescopes. Visitors are welcome any Thursday night, with guest speakers on the 1st Thursday of the month. The society also run regular open nights for the general public.

Address	Cnr Green Point & Caravan Head Roads, Oyster Bay (PO Box 31 Sutherland NSW 1499)
Times	from 8pm
Cost	Gold coin donation appreciated.
Contact	Secretary (02) 9589 1014 (voicemail phone/fax)
Email	sasi@sasi.net.au
Web	www.sasi.net.au

KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE

Located on the border of the Central Coast and Lower Hunter, the centre is no more than 2 hours from most Sydney and Newcastle suburbs. Koolang's telescopes operate seven days and nights a week. Bookings are essential. Koolang staff have also developed curriculum and theme based presentations to cover all school levels K-12.

Address	George Downes Drive, Bucketty NSW
Times	Group bookings – 7 days and nights. Individuals and families Friday and Saturday nights. Night shows start about an hour after sunset. Starting times vary, and booking is essential.
Cost	Public night shows: adults $15, concession $13, child $10; group discounts available. Special prices and hours for schools.
Contact	(02) 4998 8216
Email	staff@koolang.com.au
Web	www.koolang.com.au

SKYWATCH OBSERVATORY AND ASTRO GOLF

Skywatch Observatory is in Coonabarabran, (the home of the Siding Spring Observatory). It is open to the public day and night and is located on Timor Rd, 2km west of the Coonabarabran Clock Tower. During the day the exhibition features hands-on activities, a theatrette, computers and displays. At night there is guided telescope viewing. There is also Astro Mini-Golf, a planetarium and a restaurant/cafe.

Address	Timor Rd, 2km west of the Clock Tower
Times	10:30 am until late – Tour times vary so it is always a good idea to call ahead. Bookings not required, but appreciated, particularly during holidays. Groups welcome but please book ahead to obtain group rates. Open every day except Christmas day.
Cost	Adult $15; child/student $9; senior/pensioner $11; family $38
Contact	Merril Sana (02) 6842 3303 fax (02) 6842 2978
Email	astro@skywatchobservatory.com
Web	www.skywatchobservatory.com

MACQUARIE UNIVERSITY OBSERVATORY

Located on the Macquarie University campus at North Ryde, this observatory is open to the public on Friday nights unless raining (except Good Friday and 29th December in 2006). Astronomy students will guide you with a range of telescopes. On cloudy nights, the program includes slide shows and Solar System demonstrations.

Address Macquarie University via Culloden Rd
Times 8:30pm to 10pm (Nov–Mar), 7:30pm to 9pm (Apr–Oct).
Cost $5 per person (discounts for groups of 16 or more).
Contact Lesa Moore 0427 433 388
Email StarryLady@hotmail.com
Web www.physics.mq.edu.au/astronomy/publicObs.html

THE AUSTRALIA TELESCOPE – NARRABRI ARRAY

The Australia Telescope operates in the radio region of the spectrum. It uses high technology to combine the signals from a number of dishes, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array is located at the CSIRO's Paul Wild Observatory near Narrabri. It consists of six 22m dishes five of which are spaced along a 3km track with the sixth a further 3km to the west. From the visitor's centre there are great views of the dishes, displays and video presentations.

Address Locked Bag 194, Narrabrai NSW 2390
Times 8am to 4pm daily (unstaffed, except by request for groups (15+).
Cost No charge to visit the centre. Three weeks notice for groups.
Contact Outreach staff (02) 6790 4070
Email atnf-narrabri-outreach@csiro.au
Web www.narrabri.atnf.csiro.au

PARKES CSIRO RADIO TELESCOPE

The famous Parkes observatory, 'The Dish', is located 20km north of Parkes (just off the Newell Highway). This landmark radio telescope is 45 years old, but still considered to be one of the best single dish radio telescopes in the world. As well as a great view of the telescope, the visitors centre has displays, audiovisual and 3D presentations. There is also the Dish Cafe and a picnic area with free gas barbecues. Souvenirs and educational material are available.

Address Radio Telescope Visitors Centre, Telescope Rd (PO Box 276), Parkes NSW 2870
Times 8:30am to 4:15pm – daily except Christmas and Boxing Day
Cost Admission to the visitor's centre is free. A modest charge is made for the audio visual and 3D presentations.
Contact (02) 6861 1777
Email parkes-vdc@csiro.au
Web www.csiro.au/parkesdish

SIDING SPRING OBSERVATORY

Siding Spring is home to ten telescopes, including the Anglo-Australian Telescope — the largest in Australia. The newest is the Faulkes South, a school educational tool. Siding Spring nestles into the Warrumbungle's at the entrance to the national park, 30 minutes west of Coonabarabran. The exploratory at Siding Spring offers videos and interactive computers and much more. Guided tours are available most school holidays. Bus tours are available on booking. An open day is generally held in October.

Times 9:30am to 4pm daily except Christmas Day.
Cost Exploratory: adult $5.50, child/pensioners $3.50, family $13.50. Tours: adult $11, child/pensioner $9, family $27
Contact (02) 6842 6211, fax (02) 6842 6226
Email pstarr@mso.anu.edu.au
Web www.sidingspringexploratory.com.au/

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The complex is located 35km southwest of Canberra (Tourist Drive 5) and is a major link in NASA's Deep Space Network. Tidbinbilla sends and receives radio signals from distant spacecraft as they explore our Solar System and beyond. The centrepiece is the 70-metre antenna. The Visitor Centre incorporates audio/visual presentations, exhibits, models and images from the spacecraft. A highlight is an actual Moon rock. There is also a cafe and giftshop, where meals and souvenirs are available.

Address Tourist Drive 5, Discovery Drive (off Paddy's River Rd), Tidbinbilla
Times 9am to 5pm, 7 days per week (6pm in summer).
Email cdscc-prc@cdscc.nasa.gov
Web www.cdscc.nasa.gov/

MT. STROMLO OBSERVATORY

The oldest fully operational research observatory in Australia, Mt Stromlo Observatory (along with its sister observatory at Siding Spring) is part of the Australian National University. Once housing telescopes dating back to 1868, Mt Stromlo Observatory was devastated by the fire storms on 18 January 2003. However, Mt Stromlo Observatory is rebuilding. The site is now open for visitors, please see their website or contact them for updates on visitor programs.

Address 15 minutes from Canberra City, Mt Stromlo Observatory, off Cotter Road, Weston Creek, ACT (On Tourist Drive 5)
Times Wednesday to Sunday from 10am to 5pm. Night programs are run on Saturdays. Please contact Mt Stromlo Observatory Visitors' Centre for details.
Cost Day visits are free. Night programs are by gold coin donation.
Contact Visitors' Centre (02) 6125 0232 fax (02) 6125 0233
Email msovc@mso.anu.edu.au
Web www.mso.anu.edu.au/msovc/

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM

Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive interactive exhibits, demonstration theatre, and a gift and resource shop. The BlueScope Steel Star Theatre has a state of the art Zeiss ZKP3 star projector, laser projector and full-dome show projector. The observatory houses a high quality computer controlled telescope which is used to observe the Sun and stars.

Address Science Centre, Innovation Campus, Squires Way, Wollongong 2522
Times 10am to 4pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.
Cost Child $7, concession $8, adult $10; discount on planetarium show tickets when purchased with general entry.
Contact (02) 4286 5000 (ext 3) fax (02) 4283 6665
Email gkm@uow.edu.au
Web www.uow.edu.au/science_centre/

NEPEAN OBSERVATORY

The UWS Observatory is open to the public and runs public astronomy nights, school programs, holiday programs, and group programs during the day or evening. It features a 0.6 metre (24 inch) telescope which is available for night viewing by the public.

Cost Adult $12, child/concession $7, family $30
Contact Roslyn McCourt (02) 4736 0135
Email r.mccourt@uws.edu.au
Web sites.uws.edu.au/schools/aou/uwsn/observatory/tour.htm

CRAGO OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (north west of Sydney). It houses a 40cm Dobsonian telescope. The observatory is open on Saturday nights (nearest to Last Quarter Moon phase). Visitors are most welcome.

Address Burralow Fire Trail, Bowen Mountain
Times 8pm till late
Cost Donation
Contact Adrian Saw (02) 4572 1568
Email secretary@asnsw.com
Web www.asnsw.com/crago/index.html

CHESLEIGH HOMESTEAD

The homestead offers accommodation for couples to large groups. Chesleigh offers observing to its patrons through its 12 inch reflector telescope taking full advantage of its clean, dark sky site.

Address Chesleigh Homestead, 319 Hill End Road, Sofala 2795
Web www.sofala.net.au/astronomy.html

SYDNEY OBSERVATORY

This is Australia's oldest observatory, situated near the Rocks on Observatory Hill and overlooking Sydney Harbour. There are various interactive displays and night telescope tours, which include stargazing through the observatory's telescopes. There is also a mini-planetarium on offer during wet weather. Day tours include a dome tour and solar viewing (weather permitting). Sydney Observatory is part of the Powerhouse Museum.

Address Watson Road, Observatory Hill, The Rocks Sydney
Times 10am to 5pm, except Christmas Day. Day 3-D Theatre tours run at 11am, 12noon, 2:30pm and 3:30pm weekends and school holidays, 2:30pm and 3:30pm on weekdays. Night sessions are held every night of the week. Bookings required for evening tours. Closed Good Friday.
Cost Daytime entry to the gardens and museum is free. Daytime telescope tour & 3D Space Theatre: $6 adult, $4 child, $16 family (duration 45 minutes) Night time telescope tour and 3D Space Theatre: $15 adults, $12 students/concession, $10 children, $40 family (duration 1 hour 45 minutes).
Contact (02) 9217 0485
Email observatory@phm.gov.au
Web www.sydneyobservatory.com.au

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. It offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments, a 6" refractor and a flat screen planetarium.

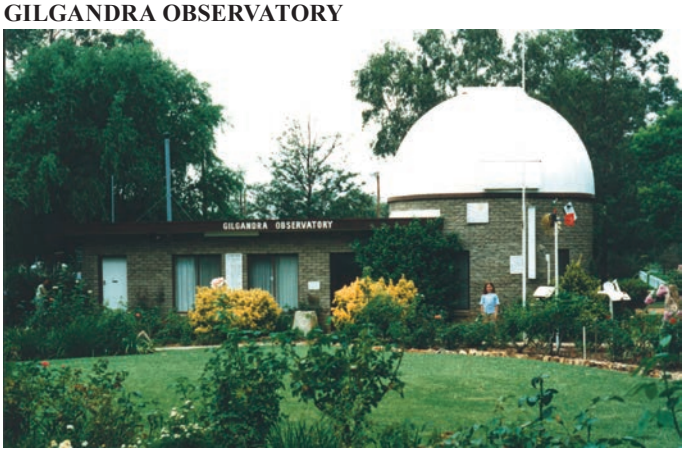
Times Winter: 7-10pm, Summer: 8:30-11pm, or by appointment. Coaches and schools welcome.
Contact Mark Monk (02) 6345 1900 fax (02) 6345 1920
Email darbysob@tpg.com.au

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. Stage one of the observatory is running, which includes viewing the night sky through three 300 mm Schmidt Cassegrain telescopes and large binoculars. There is a well-stocked gift shop. An eighteen hole mini-golf course with an astronomical theme is open during the day.

Address 13L Camp Rd (PO Box 308) Dubbo NSW 2830
Times Open daily (except Christmas) from 10am until late. Bookings essential for night sessions.
Cost Adults $13.50, family of four $42
Contact Peter Neilson (manager) (02) 6885 3022 fax (02) 6885 3012
Email DubboObservatory@hwy.com.au
Web www.hwy.com.au/~dubbobs/

GILGANDRA OBSERVATORY



The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It provides a 31cm telescope for public use. Tours of the night sky are held each night except Sundays. During NSW School holidays daytime by appointment. Booking is advised.

Address Willie Street, Gilgandra NSW 2827
Times 7pm to 10pm (daylight saving 8:30pm to 10pm)
Cost Adults $9, pensioners $7, children $6, family $25.
Contact (02) 6847 2646 fax (02) 6847 2845
Email mail@gilobs.com.au
Web www.gilobs.com.au/

MAGELLAN OBSERVATORY

Located in the Southern Tablelands, Magellan has a well equipped observatory and accommodation in a dark sky location. Equipment includes an 18" telescope in a 4 metre dome, a Meade 12" LX200GPS, a Borg 5" APO refractor and a 10" F3.5 astrograph in a 2.3 metre dome. Also a wide variety of equipment for film, CCD and digital SLR imaging.

Address 461 Covan Creek Road, Lake Bathurst NSW 2580
Contact (02) 4849 4489
Email magellan@goulburn.net.au
Web www.goulburn.net.au/~magellan

KINGS TABLELAND OBSERVATORY

The observatory is located in the Blue Mountains at Wentworth Falls. It offers dark skies while still close to Sydney. It is open to any interested people or groups. There is a flat screen planetarium and two modern telescopes in a dome. Classes for the Nepean Community College are also conducted on the night sky, astrophotography and telescopes. It is also open on Saturday and Sunday from 10am to 4pm for solar observing.

Times Flexible to meet demand
Contact Roger North, Sybil Barber (02) 4757 2954
Email north.barber@bigpond.com

NORTHERN TERRITORY

MILKY WAY CAFE

The Milky Way Cafe is the first venue purpose built to tour Central Australia's night skies. It is the home of the award-winning 'Spirit of the Night Sky' tour and is open seven days.

Address Petrick Road (PO Box 7824) Alice Springs NT 0871
Times Spring/Summer (Sep – Feb) approx 8:30pm; Autumn/Winter (Mar-Aug) approx 8pm
Cost $55 adults (2 children under 15 free, additional children $30 each). Includes coffee and cake.
Contact (08) 8955 5848
Email info@landandsky.com.au
Web www.landandsky.com.au

QUEENSLAND

SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is only a 45-minute drive from Surfers Paradise. The observatory is open to the general public, astronomical groups, schools, and researchers by appointment. This facility has a C14 with Titan Robotic Mount, C11, 4.5 inch refractor, CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing.

Address 2319 Springbrook Road, Springbrook Qld 4213
Times By appointment
Cost Adults $10, children $5
Contact Andre Clayden (07) 5533 5200 fax (07) 5533 5457
Email springbrook@iprimus.com.au
Web www.maguires.com/astronomy/

ALLOWAY OBSERVATORY

The observatory, situated approximately 6 km South of Bundaberg, is operated by The Bundaberg Astronomical Society. The 6 metre dome houses a 480mm Newtonian telescope and a 14 inch computerised Meade telescope with CCD imaging using ST8E and Starlight Express technology. The observatory opens to the public on Friday nights. Midweek opening can also be arranged for large groups.

Address PO Box 4221 South Bundaberg Qld 4670
Times Every Friday night, other nights by appointment.
Cost $12 family; $6 adults; $3 child, discounts for groups.
Contact Mac Jonsen (07) 4153 6469 or (07) 4159 7232 (ans. service)
Email macsen2@yahoo.com

THE GREAT BARRIER REEF OBSERVATORY

Situated on Hamilton Island, the observatory is open to the public regularly during the dry months from April to November. Special openings on request. The observatory enjoys dark skies, operates five telescopes, and is staffed by members of the island's astronomical group. Viewing is complimentary.

Address PO Box 40, Hamilton Island Qld 4803
Contact Ray Johnston (07) 4946 8686
Email star@whitsunday.net.au

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the Brisbane Botanic Gardens, Mt Coot-tha, at Toowong in Brisbane. Programs are presented in the Cosmic Skydome which has an artificial sky projected onto the interior of a 12.5m dome. The Planetarium has been upgraded and is now in a digital format. All shows include a current night sky tour recreated in the Skydome. The display areas contain interesting astronomical/space items, short videos run in a mini theatre, and the shop has astronomical/educational products. The Planetarium observatory has a variety of telescopes and sessions must be pre-booked. School shows are also available during weekdays.

Address Brisbane Botanic Gardens Mt Coot-tha, Mt Coot-tha Rd, Toowong Qld 4066
Times Tuesday-Friday: School Shows and one afternoon Public Show. Saturday/Sunday: Multiple Public Shows and Children's Shows. School Shows are on a booking basis only. Additional weekday shows run during Queensland school holidays
Cost Admission and show charges apply.
Contact (07) 3403 2578
Email bop@brisbane.qld.gov.au
Web www.brisbane.qld.gov.au/planetarium/

COSMOS CENTRE CHARLEVILLE

The public observatory is located on Cunnamulla Rd, near the airport. The Centre includes an observatory and day interpretative centre. The observatory houses three 12 inch Meade telescopes and a new Anssen 20 inch telescope arrives early 2006.

Address PO Box 681, Charleville Qld 4470
Times Day Interactive Centre 10am – 6pm, observatory sessions from 7:30 (bookings essential)
Cost Observatory session: $19 single, $45 family, $16 student/senior Interactive Centre: $10 single, $25 family, $9 student/senior combination: $23 single. $50 family, $21 student/senior
Contact Jane Morgan (07) 4654 3057
Email cosmosob@bigpond.net.au
Web www.murweh.qld.gov.au/cosmos/cosmos.html

SOUTH BURNETT – MAIDENWELL OBSERVATORY

The observatory is located in the heart of Maidenwell, 2.5 hours drive NW of Brisbane. They are open 6 days and 7 nights a week and have daytime viewing sessions of bright stars and planets including a live video image of the Sun in Hydrogen Alpha light projected onto a giant screen. At night viewing is available through the three Meade 14" telescopes. They give presentations to schools and social groups and have full wheelchair access. The roll off roof observation deck can sit up to 30 people at a time. They sell equipment and conduct a Basic Astronomy Course twice a year.

Address 4150 Kingaroy-Cooyar Rd, Maidenwell Qld
Times Spring/Summer: Open from 2pm. Night sessions 7:30 pm / 9pm. Autumn/Winter: Open from noon. Night sessions 7pm / 8:30pm.
Cost Day sessions: $5.50 pp. Night sessions: adult $11, student $5.50, pensioner $8.80. Special rates for group bookings and schools.
Contact Bookings are essential for both day and night viewing sessions. Phone (07) 4164 6205; Fax (07) 4164 5718; Observatory: (07) 4164 6194 and Mobile 0427 961 391.
Email email@sbstars.com
Web www.sbstars.com/

SOUTH AUSTRALIA

THE HEIGHTS OBSERVATORY

The Heights School Observatory is located at the Heights School, Modbury (Adelaide). It was formed primarily for students of the school with an interest in astronomy, but anyone is encouraged to join. There are two main telescopes and a classroom. During the day solar observations are made.

Web theheights.webzone.net.au/observatory.shtml

ARKAROOLA WILDERNESS SANCTUARY AND RESORT

Located in the heart of the Northern Flinders Ranges, Arkaroola have Advanced Ecotourism accredited ridgetop, waterhole and astronomy tours. There are also many guided and unguided bushwalks. They have three astronomical observatories offering two Celestron 360mm and three Meade Maksutov-cassegrain computer assisted telescopes. There are also three 'star chairs' with 20x80 astro binoculars, spare piers and wedges suitable for BYO telescopes and astrophotography/CCD equipment.

Address Private Bag 106, Port Augusta SA 5710
Times Tours run nightly on demand and weather permitting.
Cost Cost is $30 (1.5 to 2.0 hour per tour)
Contact (08) 8648 4848 fax (08) 8648 4846
Email res@arkaroola.com.au
Web www.arkaroola.com.au

UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM

The planetarium has sessions for primary/secondary schools as well as the general public. Sessions are by appointment only. An open to the public session is available on the first Saturday of the month at 3pm.

Address University of South Australia, Building P, Mowson Lakes Campus
Cost $4.40 adults, $3.30 students and concession
Contact (08) 8302 3138
Email jean.radice@unisa.edu.au
Web www.unisa.edu.au/planetarium/

WOOMERA OBSERVATORY

The observatory houses a 10 inch LX200 Meade, an ST7 CCD and 35mm accessories. The telescope is controlled by computer with either Sky IV or Cartes du Ciel. BYO flash disk or floppy disk if CCD imaging.

Address PO Box 161, Woomera SA 5720
Times Viewing can be virtually any night.
Cost $10 pp or $20 per family for 2-3 hour viewing
Contact Rob Dillon c/o the Woomera Post office

INTERNATIONAL CANGAROO PROJECT

The CANGAROO III telescopes are used for high-energy astrophysical studies of pulsars, supernovae, gamma ray bursts and black holes. They are four 10m diameter light collecting telescopes which are used for detecting optical light which is produced when very high energy gamma-rays reach our atmosphere. The telescopes are located inside the Woomera Security Area. There is a display in the Woomera Heritage Centre.

Web www.physics.adelaide.edu.au/astrophysics/cangaroo.html

TASMANIA

LAUNCESTON PLANETARIUM

The planetarium is in the Queen Victoria Museum, Wellington St.

Address Queen Victoria Museum, Wellington St, Launceston Tas 7250
Times Tuesday to Friday 3pm, Saturday 2pm and 3pm. During government school holidays, shows run Monday to Saturday 2pm and 3pm. Group bookings by arrangement.
Cost $3 children (under 15), $5 adults and $12 family (children under 5 years old are not admitted).
Contact (03) 6323 3777
Email martin@qvmag.tas.gov.au
Web www.qvmag.tas.gov.au/planetarium.html

VICTORIA

ASTROTOURS

The Centre for Astrophysics and Supercomputing at Swinburne University of Technology is offering public 3D tours through the Universe in the Virtual Reality theatre during the school holidays.

Address The Virtual Reality theatre is in room AS406 on the fourth floor of the Applied Science building. Enter from Burwood Road.
Contact Vicki Redrup (03) 9214 5569 (bookings)
Email astrotour@swin.edu.au
Web astronomy.swin.edu.au/astrotour/

BALLARAT MUNICIPAL OBSERVATORY

The observatory contains three historic telescopes: The Jelbart — a 125mm refractor, the Oddie — a 220 mm Newtonian and the Baker Great Equatorial Telescope — a 650mm Newtonian, which was commissioned in 1886. There are a number of other telescopes including a computer-enhanced, disabled-access 406mm Cassegrain. The observatory is open Friday and Saturday nights plus other nights and daytime tours by arrangement.

Times Fri-Sat from 7pm, add 1 hr for Summer Time.
Cost $8 adults, $7 conc., $5 child, $22 family, $4 school students.
Contact (03) 5332 7526
Email bas@cbl.com.au
Web observatory.ballarat.net/

GRAMPIAN STARS

The observatory is approximately 250 km west of Melbourne, on a dark sky site 20 km south from Stawell, off the Western Highway. A 356mm SCT robotic telescope, which includes computerised CCD imaging technology, will be online in early 2006. Regular weekend viewing by interested persons or groups and accommodation is available by prior arrangement. Contact Robert & Kerrie Freund

Email info@grampianstars.com.au
Web www.grampianstars.com.au/astro_index.htm

MELBOURNE OBSERVATORY

The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. There is a self guided tour available 7 days per week. There are also occasional evening tours, contact them for details.

Address Birdwood Avenue, South Yarra Vic 3141
Times Self guided day tour 10am-4pm, Mon – Sun. Night, 7:30-9pm Tues.
Cost Day tour: $2 per person. Night tour: $15.50 adult $11 concession, $37.50 family (2+2)
Contact Visitor Centre, Observatory Gate (03) 9252 2429
Email rbg@rbg.vic.gov.au
Web www.rbg.vic.gov.au/rbg_melbourne/visitorinfo/whats_on

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages. The planetarium is open seven days a week from 10am and runs special evening sessions from January to March.

Address 2 Booker St, Spotswood Vic
Cost see web site
Contact (03) 9392 4800
Email mvplanet@museum.vic.gov.au
Web www.museum.vic.gov.au/planetarium/index.html

TALBOT OBSERVATORY

The observatory is located next door to Talbot Post Office. Talbot is a small town in a dark sky site between Ballarat and Maryborough. The two observatories house a 0.5m cassegrain reflector, and a 15cm long focus refractor for planetary work. There are nightly sky tours and informal talks. Comfortable accommodation is also available (two bedroom unit).

Address 9 Camp St, Talbot Vic 3371
Times Open every Friday and Saturday nights, all year, 7pm in winter, and 9pm in summer-time. On other nights, groups can be accommodated by arrangement.
Cost adult $8, children 8-13 $4, under 8 free.
Contact Robert Holmes (03) 5463 2029
Email ussr@hotkey.net.au
Web www.ballarat.com/talbot/observatory.htm

WESTERN AUSTRALIA

PERTH OBSERVATORY

Situated in the Darling Ranges, 40km inland from the West Coast, Perth Observatory conducts astronomical research and educational activities. As part of the Observatory's public education program, several telescopes are available for use by visitors. Astronomers also take telescopes to conduct Field Nights at various locations. A portable display is available for use at public libraries and schools. There is a museum displaying instruments from the old observatory, paintings and astrophotographs.

Address Walnut Rd, Bickley
Times Normal office hours: 8:30am – 4:30pm.
Star Viewing Nights: September to May – times vary with sunset. Bookings essential. No viewings May – September. Tour lasts 1.5 hours approx.
Daytime Guided Tours: 10am and 12:30pm, by appointment only – bookings essential.
Cost All services attract charges, contact the observatory for details.
Contact (08) 9293 8255 fax (08) 9293 8138 info line (08) 9293 8109
Email perthobs@calm.wa.gov.au
Web www.wa.gov.au/perthobs/

PINGELLY HEIGHTS OBSERVATORY (ASTRO VENTURES)

This facility specialises in the presentation of astronomical information and the viewing of the night sky through their telescopes. The observatory is one and a half hours drive from Perth. The property is Sunarise, Lot 11 Pingelly Heights (off Aldersyde Road), Pingelly. Astro Ventures caters for schools, various community organisations and private parties on request.

Address PO Box 512, Pingelly WA 6308
Times Summer: 7:30pm Friday and Saturday, (other nights by appointment). They are closed from May 1 to September 30.
Cost Adults $25, child/pensioner/concession $15, family (2+2) $60
Contact For further information and reservations ring Susie or Trevor on (08) 9887 0088, 0407 380 922 or write to Astro Ventures.
Email astroventures@westnet.com.au
Web members.westnet.com.au/astroventures/

SOUTHERN CROSS COSMOS CENTRE

The Southern Cross Cosmos Centre is an observatory situated in the Shire of Gingin, an hour north of Perth. Their main instrument is the 25 inch Brodie-Hall telescope. They have 5 other telescopes ranging from 11" to 16" as well as six pairs of binoculars. The SCCC specialises in school programs and community groups.

Times Open September through May only, available any night but bookings essential. 7:30pm to 10pm plus a light supper. Day time bookings include viewing the Sun through a special filter.
Cost $25 adults, $20 seniors, $10 children, $68 family of four. Phone for daytime prices.
Contact Donna or Barbara on (08) 9575 7740
Email cosmic@mail.com
Web www.sccc.asn.au

ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following are astronomy courses, events, magazines and radio programs for this year. This list is by no means intended to be exhaustive. Across the country there are no doubt many other evening courses held at various universities and colleges. Enquiries from the general public are most welcome. A number of the amateur astronomical societies also provide an invaluable service to public education by their lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change.

GENERAL

THE ASTRONOMICAL SOCIETY OF AUSTRALIA

The Astronomical Society of Australia has a website to provide links for Australian astronomy, both professional and amateur, including links to educational material.

Web asa.astronomy.org.au/

INTERNATIONAL DARK-SKY ASSOCIATION

IDA's goal is to preserve and protect the night-time environment and our heritage of dark skies through quality outdoor lighting.

Address 32 Carina Road, Turramurra NSW 2074
Contact Reg. R. Wilson (Dir. Asia / Pacific) phone/fax (02) 9488 7078
Email regrw@tpg.com.au
Web www.darksky.org/

ICEINSPACE

This is a web site dedicated to amateur astronomers in Australia. The site has some very busy and active forums, where amateurs join in discussions about all aspects of astronomy. There is also lots of astrophotography. The forums have 450 members and growing, with almost 45,000 posts (Sep 05).

Web www.iceinspace.com.au

LABNOTES – TIPS FOR TEACHERS – ASTRONOMY AND SPACE

Articles are listed and tips have been written for these articles. These tips will help you run learning activities, set homework, and guide student research. For educational purposes, you may print off pages, photocopy them and hand them to your students.

Web www.abc.net.au/labnotes/read/default.htm#astronomy

QUESTACON STARLAB

Starlab is an inflatable planetarium which can accommodate up to 30 students. Starlab presentations are available in Sydney, Melbourne, Brisbane, Wollongong in collaboration with other science centres.

Address National Science and Technology Centre, Canberra ACT 2600
Contact Outreach Programs Bookings Coordinator
(02) 6270 2800 fax 1 800 641 171
Web www.questacon.edu.au/html/starlab_planatarium.html

SPACE ASSOCIATION OF AUSTRALIA

Activities include monthly free public meetings, public displays, radio programme and a newsletter to promote understanding of astronautics.

Address PO Box 351, Mulgrave North Vic 3170
Contact Andrew Rennie
Email info@space.asn.au
Web www.space.asn.au

THE PLANETARY SOCIETY – AUSTRALIAN VOLUNTEER CO-ORDINATORS

An Australian based space exploration lobby group linked to The Planetary Society. It contains information of relevance to the Australian scene.

Web www4.tpg.com.au/users/tps-seti/index.html

TUTORIALFIND – ASTRONOMY TUTORIALS

Web page that is a search engine for astronomical tutorials.

Web www.find.com.au/tutorials/education/astronomy/

AUSTRALIA TELESCOPE OUTREACH AND EDUCATION

This site aims to provide the media and the general public with information about the Australia Telescope National Facility. They also provide educational resources on many aspects of astronomy.

Web outreach.atnf.csiro.au/

NATIONAL SCIENCE WEEK

The aim of this week is a nationwide annual celebration of Australian science and has the objective to increase public awareness of the role that science, engineering, innovation, technology and entrepreneurship play in our daily lives. Astronomy is a key component, and amateur societies are ideally placed for outreach to the public. For 2006 Science Week runs from August 12–20. See the web site for more information.

Web www.scienceweek.info.au, http://www.sciencefestival.com.au/

AUSTRALIAN SKY & TELESCOPE MAGAZINE

This is the Australian edition of the famous, 60-year-old magazine about astronomy and space science. First published in December 2004, Australian Sky & Telescope publishes 11 issues per year, with a double issue over the Christmas period. Featuring the latest news, developments in astronomy, equipment reviews and photos from readers, AS&T caters for the beginner to the seasoned observer.

Address PO Box 81 St Leonards NSW 1590
Contact (02) 9439 1955 fax (02) 9439 1977
Email info@austskyandtel.com.au
Web www.astmag.com.au

COMET TALES

This quarterly publication covers news on newly discovered comets and those observable from Australia, including histories of returning comets.

Address Greg Bryant, 7 Richards Close, Berowra NSW 2081
Fees $14 for one year (payable to Greg Bryant, credit card accepted)
Email gchbryant@hotmail.com

SKY & SPACE MAGAZINE

This is the Southern Hemisphere's first astronomy and space exploration magazine. Sky & Space has been wholly published and produced in Australia since 1988. The full-colour magazine is bi-monthly and available through newsagencies or by subscription.

Address SKY & SPACE Magazine, 23 Bronte Road (PO Box 1690)
Bondi Junction NSW 1355
Fees $7.40 in newsagencies or $41 for an annual subscription.
Contact (02) 9369 3344 fax (02) 9369 3366
Email info@SkyandSpace.com.au
Web www.SkyandSpace.com.au/public/home.html

EVENTS

NACAA 2006

Attendees to the NACAA 2004 tour the Mt Canopus Observatory near Hobart

The National Australian Convention of Amateur Astronomers is a biennial event held over Easter. The 2006 gathering will be held in Frankston, Victoria. Hosted by the Mornington Peninsula Astronomical Society.

Contact Peter Lowe
Email convenor@nacaa.org.au
Web www.nacaa.org.au/

ASTROFEST (COONABARABRAN, NSW)

Activities on this weekend include: observing, lectures, tour of Siding Spring and Skywatch Observatories, and Science in the Pub (subject to availability). This event is hosted by the Warrumbungle Mountain Motel. Dates for 2006 are November 25-27.

Email warrumbunglelodge@bigpond.com.au

ASTROFEST (PARKES, NSW)

The CWAS AstroFest is sponsored by the Central West Astronomical Society and was held for the first time on July 16-18, 2004. The AstroFest incorporates a two day conference and related activities including the David Malin Astrophotography Exhibition and Competition which is open to all amateur astrophotographers. World-renowned professional and amateur astronomers share their knowledge and experience in an exciting amateur astronomy festival. The CWAS AstroFest will be held annually in July.

Address CWAS AstroFest, PO Box 819 Parkes NSW 2870
Fees To be determined.
Contact John Sarkissian (President, CWAS)
Email John.Sarkissian@csiro.au
Web www.parkes.atnf.csiro.au/events/astrofest

VASTROC (VIC)

Victorian Amateur Astronomical Society's Conventions (VASTROC's) are held every second year (alternating years with NACAA). Activities include speakers, workshops, displays, observing and the convention dinner. For information regarding the 2007 event, contact a Melbourne based society.

VICSOUTH DESERT SPRING STAR PARTY

The VicSouth Desert Spring Star Party in 2006 will be held from November 10 to 13, at the Little Desert Lodge near Nhill in western Victoria. VicSouth is jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia, and offers a great weekend of social, astronomical and observing activities.

Address PO Box 434, Christies Beach SA 5165
Contact 0410 422 498
Email vicsouth@trilobytes.com.au
Web astronomy.trilobytes.com.au/vicsouth

ASTROFEST (DUCKADANG, QLD)

The Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours northwest of Brisbane. It has a dark sky with bunk house accommodation, room for camping and a C14 telescope (Stewart Observatory). Catered meals are available twice a day. Activities include: presentations from professional astronomers, awards, vendor sales, swap and sell and slide shows. The 2006 Astrofest is from 17th to 23rd July.

Address Lions Camp Duckadang, via Linville, Qld
Fees Prices will be posted on their webpage
Contact (07) 3274 5073 Anne-Louise Surma-Hawes (Registrar)
Email registrar@qldastrofest.org.au
Web www.qldastrofest.org.au

SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. This is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 400 people. The 2006 SPSP will be held from 31 March – 2 April.

Address ASNSW Treasurer, 28 Waratah St, Bowen Mountain 2753
Fees $40 per person or $60 per family (2 adults + children)
Contact Adrian Saw
email spsp@asnsw.com
Web www.asnsw.com/

NEW SOUTH WALES

MACQUARIE UNIVERSITY PLANETARIUM

Macquarie University now operates a mobile planetarium. It simulates the appearance of the stars in the night sky. It can be set up on campus or taken to schools. The planetarium seats a maximum of 20 adults.

Address Dept of Physics, Macquarie Uni NSW 2109
Contact Dr Alan Vaughan (02) 9850 8904 alanv@ics.mq.edu.au
Web www.astronomy.mq.edu.au

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are designed for the general public. Activities include a special guest speaker, telescopes operated by local amateurs and commercial stands. There are two such nights held each year normally in March-April and September-October (a Saturday night around First Quarter Moon). The venue is Macquarie University (off Epping Rd, North Ryde, Sydney), commencing around 6:30pm.

Address Dept of Physics, Macquarie Uni NSW 2109
Fees Adults $8, children $4, family $20
Contact Dr Alan Vaughan alanv@ics.mq.edu.au
Web www.astronomy.mq.edu.au

MACQUARIE UNIVERSITY FOUNDATION FOR ASTRONOMY

The FFA acts as a support group for astronomy activities at Macquarie University. Membership subscription is $20 per year (students $10). Through its activities it supports community education in astronomy.

Address Dept of Physics, Macquarie Uni NSW 2109
Fees $20 ($10 students)
Contact Dr Alan Vaughan alanv@ics.mq.edu.au
Web www.astronomy.mq.edu.au

MACQUARIE UNIVERSITY ASTRONOMY COURSE

A university-level unit titled PHYS270 Introductory Astronomy aims to give a broad descriptive underpinning of basic astronomical subjects and concepts with essential but minimal mathematical content. The unit is open to non-award students through the Centre for Open Education.

Address Dept of Physics, Macquarie Uni NSW 2109
Contact Dr Alan Vaughan (02) 9850 8904 alanv@ics.mq.edu.au
Web www.coe.mq.edu.au/nonawd.html

NEPEAN COMMUNITY COLLEGE COURSES

An astronomy course run at Kings Tableland Observatory in Wentworth Falls (Blue Mountains). The course is basic and practical, including how to use star charts to find your way around the night sky and setting up a telescope. There are modern telescopes housed in a 4.5m dome.

Contact Nepean Community College Penrith (02) 4721 5368
Web www.ncc.nsw.edu.au/

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an 8 week course conducted by Sutherland Astronomical Society (SAS). Each lecture is followed by observations with the society's equipment (weather permitting). Dates for 2006 course to be advised.

Address Green Point Observatory (Sutherland, Sydney)
Fees $120 per student subject to change
Contact The Education Officer (02) 9589 1014 (voicemail phone/fax)
Email education@sasi.net.au
Web www.sasi.net.au

SKYWORKS PLANETARIUM

Skyworks is a multi award winning travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups. It is authorised by the NSW Department of Education. Programs are curriculum based to suit years K-12.

Contact Geoff & Diana Zenner (02) 9610 2899, 0427 112 899, fax (02) 9753 1898
Email info@skyworks.net.au
Web www.skyworks.net.au

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY

SOLIS is an active group with the aim of bringing the ever increasing sky glow to a standstill.

Address PO Box 3002, North Turramurra NSW 2074
Contact Ken Petersen (02) 9634 1736
Email solissydney@telstra.com

Web solis.org.au

SYDNEY UNIVERSITY ASTRONOMY COURSES

The University of Sydney Centre for Continuing Education runs regular astronomy courses on the main Sydney University campus, with occasional bus tours to NSW observatories. Contact the university's Centre for Continuing Education on (02) 9351 2907 to enrol.

Address Centre for Continuing Education, University of Sydney
Fees Approximately $260 for 10 weeks
Contact John O'Byrne
email j.obyrne@physics.usyd.edu.au
Web www.physics.usyd.edu.au/~obyrne/cep/cep.html

WEA – SYDNEY OBSERVATORY COURSE

Sydney Observatory and the WEA are likely to run some beginner astronomy courses, based at the observatory, during 2006.

Contact WEA (02) 9264 2781 for cost and timetable or the web site.
Web www.weasydney.com.au

STARRY NIGHT PLANETARIUM

Marie and Philip (The Cosmic Couple) take their Starlab Planetarium to schools and community events in the Lismore/Ballina/Tweed areas. They can also be found planetary observing down at the beach.

Contact Marie and Philip (02) 6680 2448 0413 779 223
Email info@starrynight.com.au
Web www.starrynight.com.au

QUEENSLAND

BRISBANE TAFE ASTRONOMY COURSE

A course in basic astronomy is now being offered through the North Brisbane Institute of TAFE at their Ithaca Campus, Fulcher Road, Red Hill. It covers many of the fundamental concepts and techniques of astronomy.

Fees $137 for 6 x 2 hour classes and a 3 hour practical session.
Contact North Brisbane Institute of TAFE 131 248
Email astronomy@ourbrisbane.com
Web bn.tafe.qld.gov.au/courses_and_careers/ace/

FUNDING FOR ASTRONOMICAL RESEARCH

The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateurs and students. A grant is available in 2006. Applications must be received by February 28. Information on both the criteria to be met and obligations of successful applicants is available from the AAQ web site or by contacting the Association.

Address PO Box 6101, St. Lucia Qld 4067
Contact The General Secretary, Astronomical Association of Queensland
Email info@aaq.org.au
Web www.aaq.org.au

URBAN OBSERVERS

The South East Queensland Society holds a free public viewing night 'Urban Observers' at Indooroopilly High School, on the first Sunday of each month except January, and at Holland Park State Primary, Abbotsleigh St, Holland Park, on the third Sunday of each month.

Address SEQAS, PO Box 60, Everton Park Qld 4053
Contact David Larkin (07) 3844 7904 or Julie Straayer (07) 3325 2479
Email stragp@bytesite.com.au
Web www.seqas.org/

BRISBANE FIELD NIGHTS

The Brisbane Astronomical Society (BAS) holds a free public field night on the Saturday nearest to the First Quarter Moon (weather permitting) at Mt Coot-tha Lookout, from 7pm to 9pm.

Address Brisbane Astronomical Society Inc PO Box 15892, City East Qld 4002
Contact BAS Infoline (07) 3321 8511 (recorded club information service)
Email basmail@bas.asn.au
Web www.bas.asn.au/

HEAVENS ABOVE – TRAVELLING TELESCOPES IN EDUCATION

They travel to schools in Queensland and northern NSW for daytime Solar and night time presentations.

Contact 0428 113 744
Email info@heavensaboverocky.com.au
Web www.heavensaboverocky.com.au

SOUTH AUSTRALIA

STARLORE AND SOLAR SYSTEM ASTRONOMY

This is a one night course conducted at the Adelaide Planetarium around 2–3 times a year. The course emphasises how other cultures see the night sky including Indigenous Australians.

Address University of South Australia, Mawson Lakes Campus
Fees $20
Contact Paul Curnow 0402 079 578
Email paulc@ching.apana.org.au
Web ching.apana.org.au/~paulc/index.html

ASTRONOMY COURSES AT ADELAIDE PLANETARIUM

Three times a year a ten-week 'Night Sky' course is held Tuesday evenings from 7:30 pm until 10pm. Weather permitting they also observe with a 10" telescope. Also about four times a year they run a one-day 'Way to the Stars' course on a Sunday from 1pm until 6:30pm.

Fees Ten-week course $130, one-day Sunday course $29.
Contact (08) 8302 3138

TASMANIA

INTRODUCTION TO ASTRONOMY (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Canopus Hill Observatory site, usually twice a year in April/May and September/October.

Address Canopus Hill Observatory
Fees $40 per participant
Contact 0419 305 722
Email joroco@trump.net.au
Web ast.n3.net

VICTORIA

AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. The net, conducted by Russell Ward, commences each Friday at 10pm EST on 3.543 MHz (LSB). New stations and listeners are most welcome.

Email mockrdge@alphalink.com.au
Web www.asv.org.au/

ASTRONOMY 'ALIVE'

This is an introductory to intermediate level astronomy course. It includes: history, Solar System, stars, big bang, deep space, equipment and astronomy aids. Weekly viewing sessions are included with all telescopes and optical aids supplied.

Contact course leader – 0412 318125
Email ngc4755@i.net.au
Web www.telescope.i.ent.au

ASTRONOMY SHOW ON RADIO KLFM

The Bendigo District Astronomical Society has a fortnightly segment on Radio KLFM. This goes to air at 5:30pm on two Saturdays each month. KLFM can be found on 96.5 FM Bendigo and 106.3 FM Castlemaine (Victoria, Australia). The segment can also be accessed online.

Contact Bendigo District Astronomical Society
Web www.klfm.com.au/audiovault.html

THE SPACE SHOW

This show is broadcast on radio station 88.3 Southern FM (88.3 MHz), 7–8pm every Wednesday. Presented by Andrew Rennie.

Web www.southernfm.org.au/

WESTERN AUSTRALIA

ASTRO TOURS OF THE KIMBERLEY

Astro Tours operate in Broome from April to December and on Rottnest Island and southwest WA January through March. Two hour shows are run for the general public, schools, community and private groups using a selection of telescopes and binoculars.

Address PO Box 2537 Broome WA 6725
Contact Greg Quicke 0417 949 958 fax (08) 6210 1468
Email info@astrotours.net
Web www.astrotours.net/

ASTRONOMICAL SOCIETIES

The following is a list of amateur societies in Australia. A common philosophy within these organisations is the emphasis they place on public education. Enquires from anyone are most welcome, as are visitors to most meetings. This year we have omitted fees from the society listings, please contact them for details. Most societies now have web sites. We have not printed them here, but links to these can be found on the Quasar web site: www.quasarastronomy.com.au

We are keen to keep the information in this section and on our web site 'evergreen'. It would be appreciated if you could keep us informed of any changes (see p. 2 for contact details). The deadline for Astronomy 2007 will be August 1, 2006.

NEW SOUTH WALES & ACT

Astronomical Society of Coonabarabran meets on the third Wednesday each month at 7:30pm at the Imperial Hotel, John Street, Coonabarabran. Contact Paul Cass (02) 6842 2994 <cpc@aaocbn.aao.gov.au>.

Address c/- AAO Private Bag, Coonabarabran NSW 2357

Astronomical Society of NSW holds meetings twice per month at the CSIRO, Division of Radio Physics, Pembroke Rd (cnr Vimera Rd), Marsfield. Contact Adrian Saw (02) 4572 1568 <secretary@asnsw.com>.

Address GPO Box 1123, Sydney NSW 2001

Astronomical Society of the Hunter meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday each month at 7:30pm. Contact Col Maybury (02) 4937 4664 (ph/fax) <colmay@kooee.com.au>.

Address PO Box 69, Kurri Kurri NSW 2327

Canberra Astronomical Society meetings are held on the 3rd Thursday of every month starting at 8pm. (A beginners group starts one hour before the main meeting.) The venue is usually the Duffield Lecture Theatre, Mt. Stromlo Observatory, Weston, ACT. Contact John Howard (02) 6248 0552 <cas@enzerink.net>.

Address PO Box 1338, Woden ACT 2606

Centaurus Astronomical Society is located in Bathurst and holds regular meetings at the Bathurst Observatory. Contact Ray Pickard (02) 6337 3988 <info@bathurstobservatory.com.au>.

Central West Astronomical Society Inc (Parkes) meetings are held on the first Friday of the month at the Parkes Observatory Discovery Centre, commencing 7:30pm, visitors welcome. Contact John Sarkissian <President@cwas.org.au or Secretary@cwas.org.au>.

Address PO Box 819, Parkes NSW 2870

Coffs Harbour Astronomical Society Inc meetings are held first Tuesday each month at 7 pm at the Bayldon Public School, Toormina Road, Toormina. Contact Win Howard (02) 6653 2742 <whoward@tpg.com.au>.

Address 11 Yarad Place, Boambee, NSW 2450

Grafton Astronomical Society meets on the first Wednesday each month at 7pm at the Grafton Aero Club Vere Street, South Grafton 2460. Contact Mick Austin (02) 6643 1349 or Stephen Fletcher (02) 6643 3288 <jmashenden@yahoo.com>.

Hawkesbury Astronomical Association meetings are held 2nd Wednesday each month, at 7:45pm, in the Tebbutt Rooms at the The Derubbin Centre, Windsor. Contact Adrian Saw (02) 4572 1568 <haa@panthers.net.au>.

Address PO Box 670 Windsor NSW 2756

Illawarra Astronomical Society meetings are held at the Wollongong Science Centre and Planetarium on the second Tuesday each month (except January) at 8pm. Contact Yasmin Rittau (02) 4226 3584 <Secretary@ias.ozastro.org>.

Address PO Box 1814, Wollongong NSW 2500

Macarthur Astronomical Society holds meetings, with guest speakers and workshops, every 3rd Monday of the month at 7:30pm at the University of Western Sydney – Macarthur, Building 22, Room 5. Contact Ian Cook 0415 915 771 <contact@macastro.org.au>.

Address c/- Secretary, PO Box 17, Minto NSW 2566

Northern Sydney Astronomical Society Inc meets at St Ignatius College at Lane Cove and conducts regular observing nights at North Turramurra Gold Club. Contact David Moloney (02) 9876 6750 <nsas@nsas.org.au>.

Address PO Box 3002, North Turramurra NSW 2074

Port Macquarie Astronomical Association Inc meetings are held on the last Thursday of the month (except December) at 7:30pm at the observatory. Contact Matthew Wallace (02) 6584 9164 <info@pmobs.org.au>.

Address PO Box 1453, Port Macquarie NSW 2444

Shoalhaven Astronomers meet at the Nowra Hill School third Friday each month at 7:30pm. Contact <info@shoalhavenastronomers.asn.au>.

Address PO Box 1053, Nowra NSW 2541

Sutherland Astronomical Society meets every Thursday at 8pm at the Green Point Observatory near Sutherland, with the main meeting and guest speaker on the 1st and 4th Thursdays. Contact secretary (02) 9589 1014 (voicemail phone/fax) <sasi@sasi.net.au>.

Address PO Box 31, Sutherland NSW 1499

Sydney City Skywatchers meet at Sydney Observatory on the first Monday of the month at 6:30 p.m. Contact Elizabeth Cocking (02) 9398 9705

Address Sydney Observatory, Watson Rd, The Rocks NSW 2000

The Newcastle Astronomical Society meetings are held on the last Friday each month (except December), at the University of Newcastle, Lecture Theatre GP, first floor of Linguistics Building at 7:30pm. Contact Ghul Hussain (02) 4963 4529 or George Barnes (02) 4967 1057 <george.barnes@exemail.com.au;ghulhussain1@bigpond.com>.

Address c/- Dept. Physics, University of Newcastle Callaghan NSW 2308

University of New England and Northern Tablelands Astronomical Society meetings are held once per month at the Kirby Observatory on Thursday evenings close to New Moon at 6:30pm EST (Dec and Jan 8pm DST). Contact Anne Parnell (02) 6772 1859 <msharpe@une.edu.au;edbaker@epg.com.au>.

Address Ms Anne Parnell, 81 Perrott St Armidale NSW 2350

Western Sydney Amateur Astronomy Group Inc meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus. Contact <wsaag@tpg.com.au>.

Address PO Box 400, Kingswood NSW 2747

Wollongong Amateur Astronomy Club has monthly meetings on the first Thursday of the month, at 7:30 pm, at the Unanderra Community Centre, Princess Highway Unanderra. Visitors are most welcome to attend. Contact Laurie Marshall (Sec.) (02) 4297 1052 <chicolimpet@optusnet.com.au>.

Address WAAC c/o Laurie Marshall (Sec.), Surfrider Caravan Park, 1 Junction Rd, Barrack Point NSW 2528

NORTHERN TERRITORY

Alice Springs Astronomical Society holds regular monthly club meetings at 7:30pm over at the Motor Registry Office, METAL Centre, on North Stuart Hwy. Star viewing nights are held on the Saturday closest to the New Moon. Contact Dan Barnett (President) (08) 8953 8039 <barnett.downunder@bigpond.com>.

Address Box 739, Alice Springs NT 0871

Darwin Astronomy Group has monthly viewing nights during the dry season as well as other activities. All welcome. Contact Alan Caincross (08) 8927 3273 <darwinastronomy@hotmail.com>.

Gove Amateur Astronomers meets monthly for viewing nights on a Saturday close to the New Moon at their dark sky site on the Dhupma Road, or as announced in the local paper the Arafura Times and as shown in their web calendar of events. Contact Ian Maclean 0417 601 490 <goveastronomers@yahoo.com.au>.

Address PO Box 178 Nhulunbuy NT 0881

QUEENSLAND

Astronomical Association of Queensland meetings are usually held on the afternoon of the 2nd Saturday of the month at the theatrette of the Sir Thomas Brisbane Planetarium, Mt Coot-tha Botanical Gardens. See the web site for details. Contact Peter Hall (07) 3378 1173 <info@aaq.org.au>.

Address PO Box 6101, St. Lucia Qld 4067

Brisbane Astronomical Society meets the 4th Friday each month at 7:30pm at Kelvin Grove State High School Library. Contact BAS Infoline (07) 3321 8511 (recorded club information service) <basmail@bas.asn.au>.

Address PO Box 15892, City East Qld 4002

Bundaberg Astronomical Society meetings are held at Alloway Observatory every Friday at 7:30pm. The first Friday of the month are general meetings and are not held in January. Contact Mac Jonsen (07) 4153 6469 <macsen2@yahoo.com>.

Address PO Box 4221 South Bundaberg Qld 4670

Bundaberg Skywatchers meets every Friday night at 7pm, two field nights and one training night each month. Contact Karlene Galway (07) 4159 9674 <karlene@interworx.com.au>.

Address 534 Moorlands Road, Bundaberg Qld 4670

Cairns Astronomy Group holds monthly meetings from June to November, on the first Saturday of the month, at Bob's place, starting at 7:30pm. Contact Bob Dollery (07) 4058 1180 <jamesbak@bigpond.com>.

Address 18 Yurongi St, Caravonica Qld 4878

Mt. Isa Astronomy Group meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17km outside of Mount Isa). Meetings are held monthly, usually near the New Moon. Contact Len Fulham (07) 4743 5385 (AH), fax (07) 4743 3381 <lfulham@tpgi.com.au>.

Address PO Box 1556, Mount Isa Qld 4825

Redlands Astronomical Society meets at Ormiston College, Ormiston (27km SE of Brisbane) on the 2nd Tuesday of the month. Contact Ross Spence (07) 3822 5545

Address PO Box 2048, Wellington Point Qld 4160

South East Queensland Astronomical Society meets third Tuesday of the month at Chermside Library from January to November. Meetings commence at 7:30pm. Contact David Larkin (07) 3844 7904 or Julie Straayer (07) 3325 2479 <stragp@bytesite.com.au>.

Address PO Box 60, Everton Park Qld 4053

Southern Astronomical Society has monthly meetings at Pimpama State School, at Hotham Creek Road, Pimpama, on Saturdays (dates vary with Moon phase), at 7pm. Contact Kevin Dixon (07) 5537 3852

Address PO Box 867, Beenleigh Qld 4207

Townsville Astronomy Group observe on the Saturday closest to New Moon or the following Saturday if conditions are not suitable. Viewing site is at Bluewater, 30 km north of Townsville (see website for details). Contact Charles Mitchard (07) 4775 7253 <charlesmitchard@iinet.net.au>.

Address 6 Halstead St, Gulliver Townsville 4812

Tropical Stargazers has three branches – Mackay, Whitsunday, and Hamilton Island. Mackay and Whitsunday each meet every second month with monthly viewing nights — see web for details. The Hamilton Island group operate the Great Barrier Reef Observatory between April and November. Contact Michael Benedetti (Mackay) 0407 969 899; Dawn Byrne (Whitsunday) (07) 4945 1146; Ray Johnston (Hamilton Island) 0412 478 935 <star@whitsunday.net.au>.

Address PO Box 40, Hamilton Island Qld 4803

SOUTH AUSTRALIA

Astronomical Society of South Australia meetings are held on the 1st Wednesday each month (except January) at the University of Adelaide, North Terrace Campus. Contact (08) 8338 1231 <info@assa.org.au>.

Address GPO Box 199, Adelaide SA 5001

Woomera Astronomy Group meets when needed. Contact Rob Dillon c/o the Woomera Post office or Woomera Heritage Centre

Address PO Box 161 Woomera SA 5720

TASMANIA

Astronomical Society of Tasmania has general meetings at either the Canopus Observatory site at Cambridge or the Hutchins School conference centre, Sandy Bay on the last Tuesday each month except December. Contact Hobart (03) 6228 2402, Launceston – Karenne Barnes (03) 6344 7100 or Devonport – Peter Sayers (03) 6424 2588 <joroco@trump.net.au>.

Address Secretary, Mr Mark Rough, GPO Box 1654, Hobart Tas 7001

VICTORIA

Astronomical Society of Albury Wodonga meets regularly on the first Wednesday each month (except January) at Victory Lutheran College, Drages Road, Wodonga at 8pm. Contact David Thurley (02) 6040 3704 <astronomy@asaw.org.au>.

Address 1 Poplar St, Wodonga Vic 3690

Astronomical Society of Geelong meets every Friday at 8:30 pm at the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong. Contact Frank Baker 0407 345 070 <bachi1@bigpond.com>.

Address PO Box 1799, Geelong Vic 3220

Astronomical Society of Melbourne has monthly club nights and viewing in Melbourne, plus deep sky viewing from their dark sky site in Gippsland. Contact Chris Ellis 0412 318 125 <ngc4755@i.net.au>.

Address PO Box 92, Bentleigh Vic 3204

Astronomical Society of Victoria has general meetings, held at 8pm on the 2nd Wednesday each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. ASV specialist sections also hold regular meetings. Contact Linda Mockridge (Public Relations Officer) (03) 9888 7130 <mockrdge@alphalink.com.au>.

Address GPO Box 1059, Melbourne Vic 3001

Ballarat Astronomical Society holds a general meeting the 2nd Friday each month. Contact (03) 5332 7526 (society info.) <bas@cbl.com.au>.

Address PO Box 284, Ballarat Vic 3353

Latrobe Valley Astronomical Society meets each month (except Dec and Jan) at the Wirilda Park and Conference Centre, Tyers, call for details. Contact Gavan Dinsdale (03) 5174 6453 <gdinsdal@hotmail.com>.

Address PO Box 1298, Traralgon BC Vic 3844

Mornington Peninsula Astronomical Society meetings are held 3rd Wednesday each month (except Dec) at 8pm, at the senior school theatrette, Peninsula School, Wooralla Drive, Mt Eliza. Visitors are welcome. Contact Peter Skilton 0419 253 252 <skywatch@iprimus.com.au>.

Address PO Box 596, Frankston Vic 3199

Oasis Stargazers Club Mildura Inc conduct regular viewing nights, which are open to the public, and once a month have a public activity night. Contact Mark Vorwerk (sec) (03) 5024 5316 or Kerry Needs 0414 535 122 <oasisastronomy@yahoo.com.au>.

Address PO Box 378CP, Mildura Vic 3500

The Astronomical Society of East Gippsland meetings are held at Bairnsdale and Perry Bridge. Dark sky site near Bairnsdale airport. Contact Mike Finn (03) 5153 2802, 0422 904 238 <mikef1@iprimus.com.au>.

Address 53 Riley St, Bairnsdale Vic 3875

The Bendigo District Astronomical Society meets at Eaglehawk Secondary College, BDAS Club Room at 7:30pm on the fourth Wednesday each month (excluding December & January). Contact Graeme Knight (Pres) (03) 5441 5461 <contactclub@bdas.net>.

Address PO Box 164 Bendigo Central Vic 3552

WESTERN AUSTRALIA

Astronomical Group of WA (AGWA) meets at 7pm on the first Tuesday of every month (see address below), visitors are welcome. Contact Keith Williams (08) 9201 0895 <btow@iinet.net.au>.

Address 159A Scarborough Beach Rd, Mount Hawthorn WA 6016

Astronomical Society of the South West has observing nights at their observatory south of Bunbury on the two Fridays before the New Moon. Contact <mail@assw.org.au>.

Address PO Box 1100, Bunbury WA 6231

The Astronomical Society of WA Inc meets at 8pm on the second Monday of every month (except January) at the South Perth Bridge Club, cnr Brittain Street and Barker Avenue, Como. Visitors most welcome. Contact (08) 9299 6347 <aswa@aswa.info>.

Address PO Box 421 Subiaco WA 6008

GLOSSARY

Albedo The ratio of the amount of light reflected from a Solar System object to that received by it. A perfectly reflecting body has an albedo of 1.0 or 100%.

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its fainter companion.

Almanac A set of tables giving positions of Sun, Moon and planets at various times, plus other astronomical information; an ***Ephemeris***.

Altazimuth co-ordinates The angular height (***altitude***) of an object above or below the horizon and its angular direction (***azimuth***) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees or radians.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a comet, planet or minor planet most distant from the Sun. It is the opposite to ***perihelion***.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to ***perigee***

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See ***Minor Planet***.

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 AU.

Azimuth Horizontal co-ordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the ***celestial sphere***.

Celestial poles Points on the ***celestial sphere*** directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth and to which celestial bodies seem to be attached.

Circumpolar Objects in the sky which never set. To determine which objects are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum ***declination*** it must have to be considered circumpolar.

Colour index The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a ***comet***, usually the brightest part.

Comet Small icy body that orbits the Sun and produces tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least ***angular separation*** as seen from Earth. When an object is said to be in conjunction, it is with the Sun (unless stated otherwise).

Conjunction — Inferior When the Earth, an ***inferior planet*** (Mercury or Venus) and the Sun are in a line in that order.

Conjunction — Superior When the Earth and an ***inferior planet*** (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological gods, people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the whole Universe.

CST Central Standard Time.

Culmination The instant when a celestial body crosses the ***meridian***; an object culminates when it reaches its highest point above the observers horizon.

Declination (Dec) One part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (-) of the ***celestial equator*** and is similar to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how 'long or thin' an ellipse is. The closer the eccentricity is to zero, the more circular the orbit.

Eclipse When one object passes into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the ***umbra***, and penumbral if the Moon passes only through the ***penumbra*** of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. It is total when the Moon has a larger ***angular diameter*** than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

Ecliptic The plane of the Earth's orbit projected onto the ***celestial sphere***. It can also be defined as the Sun's path against the stars.

Ellipse An oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

Elongation The ***angular separation*** of two bodies. The greatest elongations of Mercury and Venus occur when the planets are at their most angular distance from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all co-ordinate data and is compatible with modern star atlases.

Equation of Time The difference between apparent and mean solar time.

Equinox The two times of the year when the Sun crosses the ***celestial equator***; vernal or spring equinox occurs about September 21st, and autumnal equinox about March 22nd.

EST Eastern Standard Time.

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our ***galaxy***.

Galaxy A large disk or ball of billions of stars and ***nebulae***. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto, (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between First and Last quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our ***galaxy*** and are seen in other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local ***meridian***.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually the reference is the ***ecliptic***.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is Mercury and Venus.

Julian date The number of days since noon on 1st January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the ***constellation*** of Dorado. From mid-southern latitudes the LMC is ***circumpolar***.

Light year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.512. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude –1 (except for the Sun which is –26.7). The faintest visible to the unaided eye are magnitude 6 (under dark skies).

Magnitude — absolute The apparent magnitude a star would have if it were placed at a distance of 10 ***parsecs*** (32.6 ***light years***).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The ***right ascension*** on the meridian equals local ***sidereal*** time.

Meteor (also Shooting or Falling Star***)*** A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of ***meteors*** that appear to originate from a small region of the sky (the radiant).

Meteor swarm (or ***stream***) ***Meteoroids*** grouped in a localised region of an orbit around the Sun (the source of ***meteor showers***).

Meteorite A ***meteor*** that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Minute of arc An angular measure (each degree is divided in 60 minutes of arc).

Nadir The point on the ***celestial sphere*** directly opposite the ***zenith.***

Nebula A cloud of interstellar gas and dust. See also ***emission, reflection*** and ***planetary nebula.***

Node One of two points at which an orbit passes through a reference plane (usually the ***ecliptic***).

Oblateness The ratio of a planet's polar to its equatorial diameter.

Obliquity The degree of inclination (or tilt) of a planet's equator to its orbital plane.

Occultation The disappearance of one celestial body behind another.

Open star cluster A loose grouping of stars numbering from a few dozen to hundreds.

Opposition When a celestial body is opposite the Sun in the sky.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 ***light years***. A parsec is defined as the distance to a celestial body whose ***parallax*** is one arc second.

Penumbra Area of partial illumination in the shadow of a planet surrounding the ***Umbra***. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth.

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to ***aphelion***.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. Thought to be the outer layers of a red giant during its latter stages of evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

Quadrature A configuration that two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

Reflection nebula. A gas cloud illuminated by a nearby star.

Retrograde motion 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.

2. Apparent retrograde motion is the westward motion of a planet with respect to the stars which occurs near opposition (outer planets) or near inferior conjunction (inner planets).

Right ascension (R.A.) Part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is similar to lines of longitude on the Earth but is measured in hours (24hrs = 360°).

Second of arc An angular measure. Each degree contains 3600 seconds of arc, and each ***minute of arc*** contains 60 seconds.

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23hrs 56m 4s of normal solar time.

Small Magellanic Cloud (SMC) Satellite ***galaxy*** to our own Milky Way system, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is ***circumpolar***.

Solstice The time when the Sun is farthest from the ***celestial equator***. In the Southern Hemisphere around June 21st marks the shortest day of the year, and around December 21st marks the longest day.

Spectral type A star's spectral classification determined by its ***spectrum***.

Spectrum The light of an object spread out like a rainbow. As well as a continuous spectrum, a star normally shows a distinctive set of dark and bright lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The period of a planet's orbit with respect to the Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the ***meridian***.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight — astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight — civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight — nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time (UT) A time system measured from the Meridian of Greenwich in England.

WST Western Standard Time.

Zenith The point directly overhead (90° in altitude).

Zenith Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming the radiant is at the ***zenith*** with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the ***ecliptic*** (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

GREEK ALPHABET

Α, α	Alpha	Ε, ε	Epsilon	Ι, ι	Iota	Ν, ν	Nu	Ρ, ρ	Rho	Φ, φ	Phi
Β, β	Beta	Ζ, ζ	Zeta	Κ, κ	Kappa	Ξ, ξ	Xi	Σ, σ	Sigma	Χ, χ	Chi
Γ, γ	Gamma	Η, η	Eta	Λ, λ	Lambda	Ο, ο	Omicron	Τ, τ	Tau	Ψ, ψ	Psi
Δ, δ	Delta	θ, ϑ	Theta	Μ, μ	Mu	Π, π	Pi	Υ, υ	Upsilon	Ω, ω	Omega

INDEX Entries which refer to diagrams or tables are in **bold** type

Adelaide, astronomical twilight **86**;
lunar occultations **95**; planet rise/set – see rise/set times; Moon rise/set **90**; Sun rise/set **86**
Analemma 51, **51**
Angles, scale **rear cover**; estimating 17
Angular size of the planets **81**
Appearance of the planets diagrams **monthly section**; explanation 17
Asterisms 59, **59**
Asteroids – see minor planets
Astronomical coordinates or positions (RA and Dec) 80
Astronomical twilight 17, **86-87**
Astronomy, clubs and societies 149-150; courses 146-148; places of interest 141-145; sources of information 146-148
Atlas, star 80
Aurora Australis 8, **8**

Bennett Catalogue 35
Binoculars 15; galaxies visible with 64, **64**
Brightest stars 135, **138**
Brisbane, astronomical twilight **86**;
lunar occultations **96**; planet rise/set – see rise/set times; Moon rise/set **90**; Sun rise/set **86**

Caldwell Catalogue 35
Callisto, viewing 27, **27**
Canberra, astronomical twilight **86**;
lunar occultations **97**; planet rise/set – see rise/set times; Moon rise/set **91**; Sun rise/set **86**
Celestial equator 80
Celestial poles 80
Central meridian, Jupiter **117**
Central Standard Time (CST) 17, 80
Clubs, astronomy 149-150
Comets 17, 130-131; ephemerides **132-133**; orbital elements 131, **131**; Schwassmann-Wachmann-3 finder **39**
Conjunction 14, 18, **18**
Constellations, abbreviations and culmination **135**; 3D 31, **31**
Courses, astronomy 146-148

Dark adaptation 14
Darwin, astronomical twilight **86**;
lunar occultations **101**; planet rise/set – see rise/set times; Moon rise/set **91**; Sun rise/set **86**
Daylight saving time 17
Declination 80; of the Sun and planets **84**
Diary of events explanation 17-18

Eastern Standard Time (EST) 17, 80
Eclipses, lunar and solar 89, **89**
Elongation 18, **18**
Epoch 2000.0, 80
Exposure, photographic **140**

Field of view 80
Finder charts, Jupiter **118**; Neptune **126**; Pluto **126-127**; Saturn **118**; Uranus **126**
Finder, reflex 55, **55**

Geocentric, phenomena **82**; positions 80
Gibbous 17
Glossary 151-152
Greek Alphabet 152

Heliocentric, phenomena **82**; positions of planets **21**
Highlights of the month, **monthly section**
Hobart, astronomical twilight **87**;
lunar occultations **101**; planet rise/set – see rise/set times; Moon rise/set **92**; Sun rise/set **87**

Julian date 140, **140**
Jupiter, belts **117**; finder chart **118**; longitude of central meridian **117**; Great Red Spot 117; position **116**; rise/set **116**; satellites **83**; satellite eclipse positions **110**; satellite events 110, **111-115**

Latitude, effect of change 18, **18**
Light pollution 14
Longitude of central meridian, Jupiter **117**;
Lunar observatories 5-7, **5-7**
Lunar occultations 94, events, bright and dark limb 94; occultation tables **95-101**; timing 94; timing equipment 94

Magnitude, definition 17
Magnitudes of the planets and major asteroids **81**
Mars, position **109**; rise/set **109**; satellites **83**
Melbourne, astronomical twilight **87**; lunar occultations **98**; planet rise/set – see rise/set times; Moon rise/set **92**; Sun rise/set **87**
Mercury, position **106**; rise/set **103**; transit of 104-105, **104-105**
Meridian passage of planets **84**
Messier, catalogue **136-137**
Meteor showers 17, 134, **134**
Minor planets 17; positions **128-129**
Moon, apogee **102**; eclipses 89, **89** ; position **102**; lunation number **102**; occultations 94, **95-101**; perigee **102**; phases **102**, **inside front cover**; rise/set **90-93**
Moon, Great Hoax 47, **47**
Movement of the planets 19, **19**

Nearer Stars 135, **138**
Neptune, finder chart **126**; position **124**; rise/set **124**; satellites **83**, **123**
Night vision 14
Non-stellar objects **137**

Occultations, lunar 94, **95-101**
Orbital aspects **18**

Parkes Radio Telescope 10-13, **10-13**
Perth, astronomical twilight **87**; lunar occultations **99** planet rise/set – see rise/set times; Moon rise/set **93**; Sun rise/set **87**
Photographic exposure guide **140**
Places of astronomical interest 141-145
Planet rise/set times, Jupiter **116**; Mars **109**; Mercury **103**; Neptune **124**; Pluto **125**; Saturn **119**; Uranus **122**; Venus **108**
Planet, definition of 17
Planets, angular size **81**; appearance of diagrams **monthly section**; declinations of **84**; general data **82**; magnitudes **81**; meridian passage **84**; movement of 19, **19**; positions of **21**
Planisphere 13, **13**
Pluto 125; finder chart **127**; pointer chart **126**; position **125**; rise/set **125**; satellite **83**
Position tables 80
Precession 80

Retrograde motion 80, **80**
Right ascension 80
Rings, of Saturn **121**
Rise/Set charts **monthly section**; how to use 17
Rise/set time adjustments for other locations 139, **139**
Rise/set times 80
Rise/set times, Jupiter **116**; Mars **109**; Mercury **103**; Moon **90-93**; Neptune **124**; Pluto **125**; Saturn **119**; Sun **86-87**; Uranus **122**; Venus **108**

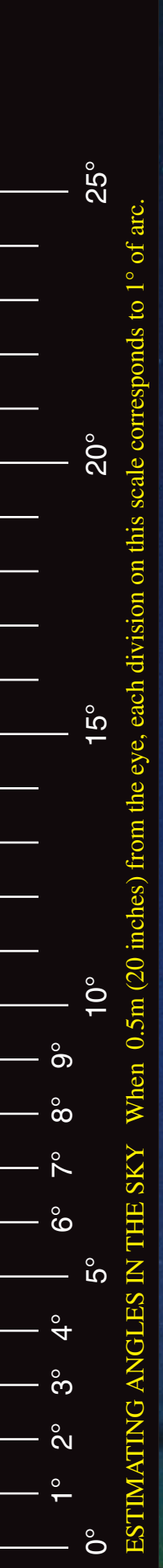
Satellites, Jupiter 110, **111-115**; Neptune **123**; Saturn **120-121**; of the Solar System **83**; Uranus **123**
Saturn, finder chart **118**, position **119**; rings **121**; rise/set **119**; satellites **83, 120-121**
Shooting stars – see meteor showers
Sidereal time 140, **140**
Sky maps 70, **71-79**
Sky view diagrams, explanation 14, 18; legend **19**; **monthly section**
Societies, astronomical 149-150
Solar System, general data **82**, satellites of **83**
South celestial pole 80
Space probes 23, **23**
Spectral classification of stars 135
Star atlas 80
Star of Bethlehem 67, **67**
Star, definition 17
Stars, brightest 135, **138**; colour and temperature 135; nearest **138**; spectral type 135
Sun, eclipses 89, **89**; orientation 88, **88**; position **85**; rise/set **86-87**; synodic rotation numbers **88**
Sydney, astronomical twilight **87**;
lunar occultations **100**; planet rise/set – see rise/set times; Moon rise/set **93**; Sun rise/set **87**

Time, central, eastern and western standard 17, 80; daylight saving 17; sidereal 140, **140**; universal 80
Transit of Mercury 104-105, **104-105**
Transit trivia, 63
Twilight, astronomical and civil 17, **86-87**

Universal time 80
Uranus, finder chart **126**; position **122**; rise/set **122**; satellites **83, 123**

Variable star 43, **43**
Venus, position **107**; rise/set **108**
Visibility of the planets 20, **20**

Waning 17
Waxing 17
Western standard time (WST) 17, 80



We are fortunate to live in Australia for the stars of the Southern Hemisphere are indeed spectacular! Have you ever gazed at the beauty of the night sky and wondered:

What is that bright star?

Which constellation is that?

Why do some 'stars' move from night to night?

Which planet is that?

Where is the Moon?

Then this book is for you. No knowledge of Astronomy is needed to enjoy this publication. Not even a telescope! Five of the planets are easily visible to the unaided eye, just look up!

Astronomy 2006 has everything you need to enjoy the night sky. With nothing other than your eyes, a sense of curiosity and a copy of this book you can start enjoying the most spectacular show nature has to offer.

Realistic drawings, easily identifying the planets from the stars

Easy to use All Sky Maps, designed for Australian stargazers

The best times to observe the planets

Easy to read monthly rise/set charts

A guide to the transit of Mercury

Public observatories in Australia

Where and when to find comets

Amateur astronomical societies

When to see shooting stars

Quasar Publishing has been producing yearbooks since 1991 and Astronomy 2006 continues with the high standard established over the years. The authors have many years experience in observational astronomy, astronomical publications, public education and the amateur astronomical community.

ISBN 0-9756070-1-4
9 780975 607015

QUASAR PUBLISHING